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Cluster analysis of capitalization of ukrainian banks in the conditions of national economy globalization

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A b s t r a c t. The conducted analysis of activity of Ukrainian banks allowed to draw conclusion about the general tendencies of banks development within the limits of clusters and testified about the reduction of profitability of equity in direct ratio to the decline of index of cartoonist of equity of the bank. The crisis processes in national and world economy have an influence on the banks of the first cluster , because the structure of their capital is formed mainly by liabilities. The banks of the third cluster, predefined by low efficiency and considerable frequent problem debt, need a recommendation to take part in M&A processes. The banks of second cluster at sufficient profitability and insignificant statistics of problem credits have a sufficient provision of equity in case any unforeseeable circumstances arise. Thus, the optima of multiple capital index are 10-20, the proportion of equity to owned capital from 4 to to10.

Key words: bank, competition strategy, bank cluster, multiplier of bank stock, qualitative composition of the owned capital, profitability of the owned capital.

INTRODUCTION

The banking system is a set of business units that are characterized by various sizes, geographical locations, client bases and ranges of services. However, if the banks are grouped according to quality criteria, it will become apparent that they are closely connected and can be incorporated in a few stable groups with identical parameters of activity, and the difference between these groups is substantial. The application of such grouping is made by means of the cluster method.

The efficiency of activity of Ukrainian banks during 2007 - 2011 was analyzed by a cluster method. In order to strengthen competitive positions of banks at the international financial market it is necessary to conduct the analysis of capitalization of their activity, investigating reasons of problems and evaluating potential of development. To that end it is necessary to solve such tasks of scientific research:

- estimate the level of reliability and profitability of activity of banks during 2007-2011;
- analyze competition positions of Ukrainian banks after the changes in the level of capitalization;
- define the list of recommendations for the competitive strategies of development of banks within the limits of clusters.

MATERIALS AND METHODS

The term "cluster" (Eng.) implies a bunch, bouquet or group, accumulation, concentration. As a mathematical term, "cluster" suggests close location of some logically related objects within one area [4, 5, 6, 11, 14, 15, 16, 17, 18].

The logic of applying the cluster method to the analysis of the functioning of the banking system consists in selecting the institutions, for which it is possible to use similar methods of regulation and analysis, application of activity criteria and determination of priorities [1, 2, 3, 8, 19, 20].

Therefore, the conducted cluster analysis will enable estimating the quality of the banking system through the evaluation of the rating of the banks in certain groups and their relocation during defined period of time. For the central bank such groups will be the basis for making recommendations on the improvement of the quality of the banks' capital and its growth with the purpose of increasing the competitiveness of the system in general and of certain banks in particular.

In addition, the identification of the group of banks with the worst indices will be a criterion for keeping a closer watch over them and, possibly, taking the measures of administrative influence.

The revealing of its position in a corresponding cluster will enable the certain bank not only to identify the institutions with similar advantages and disadvantages in the market, and, thus, to use their work experience for eliminating its own certain disproportions in activity, but also to strive for changing to another cluster, whose banks activity is more profitable and less risky.

The placing of a bank in a certain cluster is used as an additional source of information about the level of its capitalization for clients, as the choice of the bank must be based, first of all, on its reliability. Thus, choosing a certain group will determine not only the bank's provision with insurance funds (owned capital), but also a proper level of risk and profitability, that satisfies a potential contractor.

The grouping of banks must be carried out according to a logically grounded system of indices, as, depending on their choice, different combinations of banks are possible in different clusters. Certainly, within each of the basic clusters it is possible to determine smaller groups, depending on other factors. However, it does not change the closeness of connection in the group according to the top-priority criteria, but only determines additional characteristics.

For the analysis of the capitalization of the banking system we consider it necessary to use, first of all, the multiplier of bank stock (M_{h_c}) [9, 10]:

$$M_{bc} = \frac{\text{balance sheet total}}{\text{authorized capital amount}}.$$
 (1)

This index determines the level of bank provision with the authorized capital, therefore, the higher the multiplier index is, the higher the risk level of work and probability of losses. The balance sheet total or the amount of assets in the numerator determines the object of insurance for the capital, as the level of the bank's risk is determined by the volume of its active operations.

For a meaningful supplementing of the bank stock multiplier we shall calculate the index of the qualitative composition of the owned capital (Q_{ac}) :

$$Q_{oc} = \frac{authorized capital}{owned capital}.$$
 (2)

It is worth mentioning that the division of the authorized capital by the owned one determines the quality index of the bank's insurance buffer without taking into account possible manipulations and fictitiously grown constituents, on the use of which the National Bank imposes restrictions.

The next criterion of the division of banking institutions into clusters is the profitability of the owned capital (P_{oc}) :

$$P_{oc} = \frac{\text{net profit/loss}}{\text{owned capital}}.$$
 (3)

The use of this index is substantiated by the fact that every bank as a business establishment aims at receiving a profit, and this criterion is probably the most important in an economic analysis. On the basis of the index of capital profitability, in case of making a loss, it is necessary to calculate its part that can be covered by the owned capital and the safety factor that remains in the bank.

The complex of the suggested indices enables discovering clear tendencies only in dynamics, therefore we consider it expedient to make an analysis of the years 2007-2011 [7]. While doing this, for description of indices in the clusters we have used the index of arithmetic mean for totality (\bar{x}), as the calculation of the averages will make it possible to estimate the reference-points of the group:

$$\sigma = \sqrt{\frac{1}{N} \sum_{i=1}^{N} (x_i - \overline{x})^2},$$
(4)

where: N – the number of banks in the cluster;

 x_i – index value for a certain bank.

For the uniting of banks into clusters a statistical package SPSS is used, which enables to discover distinct gaps between the groups of banks, and by means of determination between the indices of authorized capital correlation and the total of liabilities (the index of approximation reliability $- R^2$) of these groups to confirm the division made.

RESULTS AND DISCUSSION

Fig. 1 represents the division of Ukraine's banks into three clusters, the first of which will comprise the banks, the size of whose multiplier exceeds thirty, the second - exceeding ten, and the third one will comprise the rest. The number of banks in the formed clusters is as follows: the first cluster comprises four banks, the second cluster – sixty-nine, the third cluster consists of ninety-nine banks.

Verification of determination availability in each of the clusters is represented in Fig. 2-4. Additional criteria for confirmation of substantial differences between the formed clusters is the construction of different equations of dependences. For the symmetry of the received results a linear function has been used for each dependence.

From Fig. 2 - 4 it is obvious that there is a considerable reliability of connection in the clusters (more than 0.8), and the dependences are described by different equations (for the Ukrainian banks from the first cluster the increase variable at x is fifty-three, for the second – seventeen, for the third – seven.

By January 1, 2009 the tendency to the division into three clusters remained unchanged. The first of them includes six banks, the second - forty-nine, the third - one hundred and twenty-seven banks in Ukraine, which means that a redistribution of banks in favour of the third cluster took place (see Figure 5). We observe a redistribution of banks in favour of the third group, namely a return to the tendencies of the previous years in Ukraine.

High reliability of connection between the banks (0.9) in the distinguished clusters and similar values



Fig 1. M_{bc} indexes (01.01.2008)



Fig. 3. Dependence between balance sheet

of increase variables are clearly exhibited by the linear equations of the first and second clusters, but in the third cluster the increase value diminished twice, which testifies to the convergence of characteristics of the banks in the cluster (Fig. 6 - 8).

We continue to observe the division into three clusters as of January 1, 2010. The first of them comprises eleven banks, the second - twenty-one banks, the third - one hundred and forty-one banks in Ukraine (Fig. 9). We notice the continuation of the tendencies toward changes







Fig. 4. Dependence between balance sheet total and stock capital of cluster 2 (01.01.2008) total and stock capital of cluster 3 (01.01.2008)

in the structure of the clusters in favour of the group that is lower in order, due to the greater influence of the financial crisis on the activity of the banks.

The high reliability of connection between the banks in the clusters and similar values of increase variables in the linear equations of the second and third clusters remained unchanged, while in the first cluster the value of increase diminished twice, which testifies to the increase in the closeness of connection within the cluster in Ukraine (Fig. 10 - 12).



Fig. 5. M_{he} indexes (01.01.2009)



Fig. 6. Dependence between balance sheet total and stock capital of cluster 1 (01.01.2009)



Fig. 7. Dependence between balance sheet



Fig. 8. Dependence between balance sheet total and stock capital of cluster 2 (01.01.2009) total and stock capital of cluster 3 (01.01.2009)



Fig. 9. M_{bc} indexes (01.01.2010)



Fig. 10. Dependence between balance sheet total and stock capital of cluster 1(01.01.2010)



Fig. 11. Dependence between balance sheet



Fig. 12. Dependence between balance sheet total and stock capital of cluster 2 (01.01.2010) total and stock capital of cluster 3 (01.01.2010)

It is necessary to point out the reappearance of the former 10 - point gap between the multiplier indices of the first and the second clusters, which resulted from the additional changes in the characteristics of the clusters due to the crisis.

In Fig. 13 we can see a division into three clusters as of January 1, 2011, the first of which comprises seven banks, the second – twenty-seven, the third - one hundred and forty-one banks. We observe changes in the structure of the first cluster in favour of the second one, thus,

a decline in the possibilities of the banks to accumulate funds in Ukraine.

In the conditions of high reliability of connection between the banks in the clusters the capital increase index tends to grow in the first cluster (due to the diminishing of the gap between the clusters the first group includes again the banks with a rather wide range of the multiplier index values -23 - 87), and similar values of increase variables in the linear equations of the banks from the second and third clusters are preserved (Fig. 14 - 16).



Fig. 13. M_{bc} indexes (01.01.2011)



Fig. 14. Dependence between balance sheet total and stock capital of cluster 1 (01.01.2011)



Fig. 15. Dependence between balance sheet



Fig. 16. Dependence between balance sheet total and stock capital of cluster 2 (01.01.2011) total and stock capital of cluster 3 (01.01.2011)

As of January 1, 2012 three clusters were distinguished in the banking system of Ukraine, the first of which included seven banks, the second – twenty-seven, the third - one hundred and forty-one banks (Fig. 17). The unchanging tendency of the structure of the clusters testifies to a certain stabilization in the Ukrainian banking system and gradual renewal of the pre-crisis parameters of the banks' activity. The high reliability of connection between the banks inherent to the clusters and similar values of increase variables in the linear equations are preserved (only the linear increase coefficient of the banks from the second cluster rose insignificantly) in the banking systems of Ukraine (Fig. 18 - 20).

The conducted analysis enables us to make conclusions concerning the similar features that are observed



Fig. 17. M_{bc} indexes (01.01.2012)





Fig. 18. Dependence between balance sheet total and stock capital of cluster 1 (01.01.2012)





Fig. 20. Dependence between balance sheet total and stock capital of cluster 2 (01.01.2012) total and stock capital of cluster 3 (01.01.2012)

in the clusters of the Ukrainian banks (appendix 1). The first conclusion is that the number of banks in the first cluster is limited, while the number of banks in the third cluster is considerable (Fig. 21).

In our opinion, the limited number of banks in the first cluster is explained by the fact that leadership in the market depends not only on the work of management, which must be organized on a high level, but also on considerable expenses connected with achieving this kind of increase, that is why only a small number of banks can reach a high level and hold this position.

The analysis of the quality of the owned capital and the bank stock multiplier in dynamics makes it possible to understand that for banks with a small multiplier the share of authorized capital in the owned capital is low (Fig. 22). We consider that this is due to the "information" potential of banks – actively developing banks with tendencies to a profit increase successfully accomplish strategic work and use marketing developments.

With time these banks can attract a considerable part of their liabilities using deposits and resources of the European financial market, which will diminish the portion of their own assets in the structure of the resource base, and subordinated obligations, which will decrease the share of the authorized funds. At the same time, the banks that do not use the publicity status, operate only in separate market segments and show low profitability, can grow mainly owing to additional payments of shareholders.

It stands to reason that a greater amount of resources and more effective activity enable getting a higher level of profit, that is why the index Poc is obviously higher in the first cluster. The tendency of five years proves the symmetry of the achieved results in the comparison of the clusters and speaks of a reduction of the owned capital profitability in direct proportion to the decline of the index of the bank stock multiplier (Fig. 23).

According to the logic of economic research, the profitability increase should have been accompanied by an increase in the non-standard debt quotient. However, there is a reverse tendency according to the received results. In the banks of the first group the risk level is lower, which can be explained by a high quality of work or by a cardinally opposite phenomenon – the mass character, in which inaccurate loans influence the quality of the combined credit portfolio to a lesser extent.

It should be pointed out that despite the best performance indices in the first group, the banks belonging to it are more susceptible to the crisis phenomena. This hypothesis is confirmed by the data of 2009, when the



Fig. 21. Dynamics of quantity in clusters



Fig. 22. Analysis of banks in clusters by index Qoc





Fig. 23. Analysis of banks in clusters by index Poc

mass outflow of deposits put two of the four banks, that firmly belonged to the first cluster, - Prominvestbank and Nadra - in danger of bankruptcy.

The other two banks – Citibank (Ukraine) and Ukrsotsbank – belong to foreign owners, therefore they were supported by the financial resources of parent structures, although now they show a considerably greater part of problem loans than during the previous years.

The banks of the third group require recommendations of the central bank concerning mergers and acquisitions owing to their low efficiency and a considerable portion of problem debts. As a result of the crisis, the ratio of the authorized capital to the owned one exceeds 1, which indicates a significant amount of reserves that have not been sufficiently formed and a reduction in the amount of the owned capital due to the losses of the previous periods.

The character of activity of most banks belonging to the group is regional or aimed at serving a limited circle of clients, that is why with the increase of requirements for the amount of the owned capital the majority of these banks will have to search for variants of consolidation, because a capital increase at the expense of shareholders or foreign market entry is improbable.

CONCLUSIONS

We must not think that the financial crisis did not affect the activity of the second cluster of banks. However, on the whole, it may be concluded that according to the criteria of stability used by the central bank the second group of banks, which at sufficient profitability and an insignificant portion of problem loans has sufficient provision of bank stock in case of contingency, remains optimal. Thus, we can recommend 10 - 27 as optimal limits of the multiplier index, that is a 4 to 10 per cent share of the authorized capital in the liabilities.

The received results confirm Michael Porter's theory of competitive advantages [12; 13]. The scientist distinguishes three types of strategies that are used by banks in certain clusters. The strategy of the least aggregate expenditures consists in reducing the expenditures on service and activity through gaining leadership in the branch and using the scale effect. While working on the realization of this strategy, banks acquire considerable experience and substantially reduce expenditures to get greater profit than the other competitors, and good organization of work contributes to a decrease in general risk of activity (in this particular case, of the quotient of non-standard loans).

This strategy is adhered to by the banks of the first cluster, higher profitability is really characteristic of them. However, the use of this strategy requires from them considerable capital investments and access to a great amount of cheap resources, which is not possible for all banks.

The banks of the second cluster use the strategy of differentiation. It presupposes the diversification of services offered to clients in various directions for maximum satisfaction of their needs. Knowing that he can complete all required operations in one certain bank, the client will not search for another bank and he will be willing to pay the price that is not necessarily the lowest; moreover, he will be willing to pay a bonus for the economy of his time and quality of service. This strategy requires paying constant attention to the range of services and qualifications of the personnel.

The use of the strategy of concentration by the banks of the third group makes it possible to satisfy a definite target group of the bank's own clients and to attain narrow specialization. This strategy does not presuppose either expenditure reduction or complete differentiation, as it is aimed at satisfying the limited needs of certain clients.

Thus, the conducted analysis has made it possible to reveal real market tendencies that confirm the theory of competitive advantages. In the course of determining the aims of its work and choosing one of the three strategies of their realization, every bank will probably find itself in a certain cluster and reach its standards. For the central bank, the belonging of a bank to the specific cluster will give the former an opportunity to formulate strategies necessary for the group of differentiated regulation and control over the indices that reveal risks in each particular case.

Indexes		01.01.2008	01.01.2009	01.01.2010	01.01.2011	01.01.2012
	Quantity banks in cluster	4	6	11	7	7
	Limits of the cluster by $M_{_{BC}}$	54-130	35-137	19-64	24-87	23-83
uster	P _{oc}	0,1813	0,1885	0,418	0,456	0,4041
1 cl	Q _{oc}	0,148	0,1479	-0,393	0,104	0,1788
	Quantity banks in cluster	69	49	21	27	27
	Limits of the cluster by $M_{_{BC}}$	10-31	12-32	12-17	12-19	12-20
uster	P _{oc}	0,5569	0,5768	0,691	0,6594	0,7299
2 cl	Q _{oc}	0,077	0,066	-0,029	0,0548	0,0368
	Quantity banks in cluster	99	127	147	141	142
	Limits of the cluster by $M_{_{BC}}$	0-9	1-11	1-11	1-11	0-11
uster	P _{oc}	0,8977	0,8294	1,411	1,1544	1,7832
3 cl	Q _{oc}	0,046	0,031	-0,553	-0,1413	-0,669

Table 1. Analysis of performance banks in clusters

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Oligopolistic market: stability conditions of the equilibrium point of the generalized Cournot-Puu model

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A b s t r a c t. The paper presents a model describing the behavior of participants of the oligopolistic market. Economic model of the oligopoly – a generalized Cournot-Puu model is constructed. Notion of Cournot equilibrium is introduced. Study on the stability of the equilibrium point of the constructed model is described. As an example, the model of duopoly is considered in detail.

Key words: oligopoly, duopoly, a generalized Cournot-Puu model, Cournot equilibrium, linearization of the system, stability, Routh-Hurwitz procedure.

INTRODUCTION

Many scientific papers have been devoted to investigations of the enterprises stability in different economic conditions. In particular, Chukhray N. studied the competition as a strategy of enterprise functioning in the ecosystem of innovations [16]. Feshchur R., Samulyak V., Shyshkovskyi S. and Yavorska N. analyzed different analytical instruments of management development of industrial enterprises [21]. Moroz O., Karachyna N. and Filatova L. studied economic behavior of machine-building enterprises in analytic and managerial aspects [26]. In turn, Petrovich J.P. and Nowakiwskii I.I. analyzed the modern concept of a model design of an organizational system of enterprise management [28]. In this article we examine the behavior of enterprises in oligopolistic market.

Two main types of market structure without high competition are described in the scientific literature. This is an oligopoly and oligopsony. *Oligopoly* is a such market structure in which a few large manufacturing firms dominates. *Oligopsony* is a market structure in which a few large customers dominates. When they say "big three", "big four" or "big six", then we are talking about oligopoly.

Oligopoly is a market structure in which the small number of rival firms dominates in the same sector. One

or two of them produce a significant share of production in this industry. The emergence of new vendors is difficult or impossible. Typically, there are from two to ten firms in oligopolistic markets. They account for half or more of total product sales. In such markets all or some of the firms obtain substantial profit in the long time interval, because entry barriers make it difficult or impossible to input of firms-newcomers to the market of this product. A product may be *homogeneous* (standardized) and *heterogeneous* (differentiated) on the oligopolistic market. If the market sells a homogeneous product (i.e., buyers have no choice), we are dealing with *homogeneous oligopoly*, and if the various product (i.e., buyers can choose according to their preferences), we are dealing with a *heterogeneous oligopoly* (differentiated oligopoly) [19].

Oligopoly is the predominant form of market structure. Automotive industry, steelmaking industry, petrochemical industry, electrical industry, energy industry, computer industry and others belong to oligopolistic industries. In the oligopolistic markets, some of the firms can exert influence on the product price because they cover a significant share of its products in total manufactured product. Sellers are aware of their interdependence in this market. It is assumed that each firm in the industry recognizes that a change in its price or output provokes a reaction with other firms. The reaction, which is one of the oligopolist firms expects from competing firms in response to changes in prices established by it, output of production or changes in the marketing strategy is the main factor that determines its decision. Such reactions can influence the equilibrium of oligopolistic markets.

Sufficiently large number of models describing the behavior of firms in oligopolistic market is known today.

Oligopolistic markets are distinguished after this sign, or their members-oligopolists operate completely independently of each other, at their own risk, or, alternatively, enter into a conspiracy that may be obvious, open or secret (closed). In the first case, we usually say about *noncooperative oligopoly*, and in the second case we say about *cooperative oligopoly*, one of the forms of which is a cartel.

Obviously, when we analyze the behavior of oligopolists operating completely independently of each other, i.e. in the case of noncooperative oligopoly, differences in assumptions regarding the reaction of competitors are crucial. Depending on what oligopolist chooses control variables – the value of output or price – we distinguish oligopoly of firms that set the value of output, called *quantitative oligopoly*, and oligopoly of firms that set price, called *price oligopoly*.

There are models of quantitative oligopoly: Cournot model (*Antoine-Augustin Cournot, 1838*), Chamberlain model (*Edward Hastings Chamberlin*), and Stackelberg model (*Heinrich von Stackelberg*), which offers an asymmetric behavior of oligopolists; and models of pricing oligopoly: Bertrand model (*Joseph Louis François Bertrand, 1883*), Edgeworth model (*Francis Ysidro Edgeworth*) and Sweezy model (*Paul Sweezy*).

Let us consider Cournot model, from which the modern theory of oligopoly began. Basic model of oligopoly was proposed in 1838 by the French mathematician and economist Antoine Augustin Cournot. In the work [17, 30] he posed the problem of oligopolistic interdependence and the need for each firm in determining its market strategy to take into account the behavior of competitors.

Cournot considered duopoly, i.e. situation when there are only two firms on the market. It is assumed in this model that both firms produce a standardized product (with the same parameters) and know the market demand curve. Based on this, each firm determines its output, taking into account that its competitor also make decisions about their own output similar product. Moreover, the final price of the product will depend on the total production (both firms together) that hits the market.

Thus, the essence of Cournot model is that each firm takes the output of its rival constant. Based on the data and information about the market demand for the product, the firm makes its own decision on the establishment of such volumes of its production, which would provide the maximum profit (based on compliance with the rules of equality of marginal revenue and marginal cost). Thus, the main problem of this model is to determine at which of output both firms reach equilibrium.

Cournot oligopoly model is the most actively studied, although initially the Cournot ideas have been criticized for their simplicity. Various modifications of the model have been made by many scientists. This enabled to improve it.

In particular, T. Puu in 1991 [29], while studying Cournot model, introduced another type of economic conditions, i.e. iso-elastic demand with different constant marginal costs, under which meaningful unimodal reaction function were developed. Since the model has been discussed in numerous amounts of publications [13, 32]. Several models were generalized by using adaptive rules and heterogeneous participants [5, 7, 8, 9, 10, 12, 37]. New properties of the Cournot-Puu model were proposed by T. Puu in one of his recent publications [36].

The research of Cournot model showed that it has an ample dynamic behavior. Some authors considered the quantitative oligopoly with homogeneous expectations and found a variety of complex dynamics, such as the appearance of strange attractors with fractal dimensions [2, 3]. The complex chaotic behavior in Cournot-Puu duopoly model has been studied in recent works [7, 14, 22].

Discrete dynamics of the triopoly game with homogeneous expectations is considered in the following works [1, 6]. The authors of these works have shown that the dynamics of Cournot oligopoly games may never reach the point of equilibrium and in the long run bounded periodic or chaotic behavior may be observed. Model with heterogeneous players were studied later, like in the works [18, 23].

B. Rosser also made its contribution to the theory of oligopoly. In the work [33] he made a detailed review of the theoretical development of oligopoly, namely, heterogeneous expectations, dynamics and stability of the market. Onozaki et al. investigated the stability, chaos and multiple attractors of heterogeneous two-dimensional cobweb model in the paper [27].

Recent studies of the duopoly and triopoly dynamics of Cournot model with heterogeneous players are presented in the works [4, 5, 19]. Problems of construction and study of models with N heterogeneous players are alternative in this direction.

Considering the numerous studies that show the chaotic dynamics in the Cournot-Puu oligopoly model (duopoly and triopoly model with homogeneous and heterogeneous players), there is the problem of control the chaos that occurs in these models. Some methods, such as DFC-method [15], OGY-method for controlling the chaos, pole placement method [24] were applied to the Cournot-Puu duopoly model. But studies of oligopolistic market only in case of duopoly is very limited, and therefore the question of building a generalized model arises naturally.

Some aspects of the nonlinear model of oligopoly in the case N firms were considered in recent works [25, 31]. Therefore, our alternative future research is to build a generalized model of Cournot-Puu and to investigate the stability of the equilibrium point and to apply of methods of control the chaos that occurs in this model.

In this work the generalized model of oligopoly Cournot-Puu is considered and the concept of Cournot equilibrium is introduced. A significant result is to establish conditions under which the equilibrium point is stable.

GENERALIZED COURNOT-PUU MODEL

To construct a model, we need to describe the behavior of market participants: motivation of their behavior, conditions in the market and the restrictions which they face. Let *n* firms operate in an oligopolistic markets, $n \ge 2$. (If n = 1 we have a situation of monopoly.) Denote the oligopolist firms by F_1, F_2, \dots, F_n , which produce quantities q_1, q_2, \dots, q_n respectively. Let's introduce assumption of Cournot and Puu to get the reaction functions.

Cournot assumption (generalized). Each firm i (i=1,2,...,n) expects its rival j (j=1,2,...,n, $j \neq i$) to offer the same quantity for sale in the current period as it did in the preceding period.

According to this assumption, the general reaction functions of each firm are as follows:

$$q_{1}(t+1) = f_{1}(q_{2}(t), q_{3}(t), ..., q_{n}),$$

$$q_{2}(t+1) = f_{2}(q_{1}(t), q_{3}(t), ..., q_{n}),$$

$$....$$

$$q_{n}(t+1) = f_{n}(q_{1}(t), q_{2}(t), ..., q_{n-1}).$$
(1)

Reaction function is a curve that shows the output produced by one firm for each given output of another firm. The set of points on the reaction curve shows what the reaction will be of one of the firms (when choosing the amount of own manufacture) to the decision of other firms regarding their output. Thus, each of the functions $q_i(t + 1)$ is a reaction curve of oligopolist *i* on output offered by other oligopolists.

Puu assumption 1 (generalized). The market demand is assumed to be iso-elastic, so that price p is reciprocal to the total demand q, i.e., p = 1/q.

Puu assumption 2 (generalized). Goods are perfect substitutes, so that demand equals supply, i.e., $q = q_1 + q_2 + \dots + q_n$.

Puu assumption 3 (generalized). The competitors have constant but different marginal costs, denoted by c_i , i = 1, ..., n.

Based on these assumptions, the profit of firm F_i (*i*=1,2,...,*n*) becomes:

$$U_{i}(t+1) = \frac{q_{i}(t+1)}{q_{i}(t+1) + \sum_{j=1, j \neq i}^{n} q_{j}(t)} - c_{i}q_{i}(t+1).$$
(2)

Each of e firms wants to reach such output that would maximize its income:

$$\frac{\partial U_i(t+1)}{\partial q_i(t+1)} = \frac{q_i(t+1) + \sum_{j=1,j\neq i}^n q_j(t) - \left(1 + \sum_{j=1,j\neq i}^n \frac{\partial q_j(t)}{\partial q_i(t+1)}\right) q_i(t+1)}{\left(q_i(t+1) + \sum_{j=1,j\neq i}^n q_j(t)\right)^2} - c_i = 0.$$
(3)

Hence, given the Cournot assumption that:

$$\frac{\partial q_{j}(t)}{\partial q_{i}(t+1)} = 0, \quad i \neq j,$$
(4)

obtain the equation:

$$\sum_{j=1, j\neq i}^{n} q_{j}(t) - c_{i} \left[q_{i}(t+1) + \sum_{j=1, j\neq i}^{n} q_{j}(t) \right]^{2} = 0, \quad i = \overline{1, n}.$$
(5)

The solutions of equations (5) are the reaction function for firms F_1, F_2, \dots, F_n . Then we will have a system of equations:

$$q_{i}(t+1) = \sqrt{\sum_{j=1, j\neq i}^{n} \frac{q_{j}(t)}{c_{i}}} - \sum_{j=1, j\neq i}^{n} q_{j}(t), \quad i = \overline{1, n}.$$
 (6)

We need to solve the system (6) to find the equilibrium points. We obtain two equilibrium points: a trivial $(\underbrace{0,0,\ldots,0}_{n})$ and non-trivial $(q_1^*,q_2^*,\ldots,q_n^*)$. All the future research will deal with the only nontrivial point, called the *Cournot equilibrium* or *Nash equilibrium*.

The value of the equilibrium point we can write as:

$$q_{i}^{*} = (n-1) \frac{-(n-2)c_{i} + \sum_{j=1, j \neq i}^{n} c_{j}}{\left(\sum_{j=1}^{n} c_{j}\right)^{2}}, \quad i = \overline{1, n}.$$
(7)

METHODOLOGY OF THE EQUILIBRIUM POINT STABILITY ASSESSMENT

Let us investigate the stability of the equilibrium point $(q_1^*, q_2^*, ..., q_n^*)$. We linearize the system (6) at the equilibrium point. Denote:

$$\delta q_i(t) = q_i(t) - q_i^*, \quad i = 1, 2, ..., n,$$
 (8)

and proceed to deviations:

$$\delta q_{i}(t+1) + q_{i}^{*} = \sqrt{\sum_{j=1, j\neq i}^{n} \frac{q_{j}^{*}}{c_{i}}} - \sum_{j=1, j\neq i}^{n} q_{j}^{*} + \sum_{j=1}^{n} \left[\frac{\partial q_{i}(t+1)}{\partial q_{j}(t)} \right]_{(q_{1}^{*}, q_{2}^{*}, \dots, q_{n}^{*})} \cdot \delta q_{j}(t), \quad i = \overline{1, n}.$$
(9)

We linearize the system (9), substitute the value of the equilibrium point (7) and write the resulting system in matrix form:

$$\delta q(t+1) = J \cdot \delta q(t), \tag{10}$$

where:

$$\delta q(t+1) = (\delta q_1(t+1), \delta q_2(t+1), ..., \delta q_n(t+1))^T, \delta q(t) = (\delta q_1(t), \delta q_2(t), ..., \delta q_n(t))^T.$$
(11)

J is Jacobi matrix of the linearized system:

$$J = \begin{bmatrix} 0 & p_1 & \dots & \dots & \dots & \dots & \dots & p_1 \\ p_2 & 0 & p_2 & \dots & \dots & \dots & \dots & p_2 \\ \dots & \dots \\ p_i & \dots & \dots & p_i & \underbrace{0}_{i-\text{th position}} & p_i & \dots & p_i \\ \dots & \dots \\ p_n & \dots & \dots & \dots & \dots & \dots & p_n & 0 \end{bmatrix},$$
(12)

elements p_i of this matrix are given by:

$$p_{i} = \frac{c_{1} + c_{2} + \dots + (3 - 2n)c_{i} + \dots + c_{n}}{2(n-1)c_{i}}, \quad i = \overline{1, n}.$$
 (13)

The stability of system (10) is governed by its characteristic equation:

$$\det(J - \lambda I) = 0, \tag{14}$$

or

$$\lambda^{n} + a_{1}\lambda^{n-1} + \dots + a_{n-1}\lambda + a_{n} = 0.$$
(15)

As it is known [34], the construction of the analytical form of the coefficients of the characteristic polynomial (15) can be carried out using the principal minors of Jacobi matrix *J*.

The coefficient at λ^{n-1} is equal to the trace of the matrix, taken as negative. As in our case all diagonal elements are equal to zero, then:

$$a_1 = -trJ = 0. \tag{16}$$

Free member a_n of the characteristic polynomial (15) of Jacobi matrix *J* is equal to the determinant of this matrix multiplied by $(-1)^n$ where *n* is the order of matrix. So:

$$a_{n} = (-1)^{n} \begin{vmatrix} 0 & p_{1} & \dots & p_{1} \\ p_{2} & 0 & \dots & p_{2} \\ \dots & \dots & \dots & \dots \\ p_{n} & p_{n} & \dots & 0 \end{vmatrix}.$$
 (17)

We construct coefficients a_i , $i = \overline{2, n-1}$ at λ^m , $m = \overline{n-2, 1}$ by the formula:

$$a_{i} = (-1)^{n-m} \sum_{j=1}^{k} \Delta_{j}, \quad i = \overline{2, n-1},$$

$$m = n-i, \quad k = {n \choose i} = \frac{n!}{i!(n-i)!},$$
(18)

where: Δ_j , $j = \overline{1,k}$ are the principal minors of Jacobi matrix J of order n - m, formed by deletion of m rows with numbers i_1, i_2, \dots, i_m and m columns with the same numbers.

By the well-known theorem of von Neumann, the equilibrium point $(q_1^*, q_2^*, ..., q_n^*)$ is asymptotically stable if for all its eigenvalues λ of Jacobi matrix *J* the following condition holds:

$$|\lambda| < 1. \tag{19}$$

Consider the space A of all coefficients of the characteristic polynomials of the order n. Condition (19) defines in this space the geometrical domain of asymptotical stability. The analytical description of this stability domain can be constructed with the help of the classical Routh-Hurwitz procedure in the form of non-linear inequalities. This procedure can be described as follows [34].

At first we construct the parameters:

$$b_0 = \sum_{i=0}^n a_i$$
, where $a_0 = 1$, $b_1 = \sum_{i=0}^n a_i (n-2i)$,

$$b_{r} = \sum_{i=0}^{n} a_{i} \sum_{k=0}^{n} (-1)^{k} {\binom{n-i}{r-k}} {\binom{i}{k}},$$

where: $\binom{i}{k} = \begin{cases} \frac{i!}{k!(i-k)!}, & i \ge k, k \ge 0, \\ 0, & i < k, \\ 0, & k < 0, \end{cases}$ (20)

$$b_n = 1 - a_1 + a_2 - \dots + (-1)^{n-1} a_{n-1} + (-1)^n a_n.$$

Then we construct the matrix:

$$\begin{pmatrix} b_1 & b_3 & b_5 & \dots & \dots & \dots \\ b_0 & b_2 & b_4 & \dots & \dots & \dots \\ 0 & b_1 & b_3 & \dots & \dots & \dots \\ 0 & b_0 & b_2 & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots & \dots \end{pmatrix}.$$
(21)

and its principal (diagonal) minors Δ_r , $r = \overline{1, n}$ of order r, that are built from the first r column and the first r row of the upper left corner of the matrix.

The conditions of asymptotical stability are:

$$b_0 > 0, \quad \Delta_r > 0, \quad r = 1, 2, ..., n,$$
 (22)

and the boundaries of the stability domain in the space *A* determined with the help of the above-described Routh-Hurwitz procedure by the non-linear equalities:

$$b_0 = 0, \quad \Delta_r = 0, \quad r = 1, 2, ..., n.$$
 (23)

On the boundaries (23) the absolute values of some eigenvalues of the Jacobi matrix are equal 1 and the plethora of different bifurcation phenomena exist [34].

where:

Detailed description of the Routh-Hurwitz procedure for two- and three-dimensional case, and geometric construction of the stability domain is considered in studies of M. Sonis [34, 35].

STABILITY OF THE EQUILIBRIUM POINT OF THE COURNOT-PUU DUOPOLY MODEL

As an example, in this section we will explore in detail the stability of the Cournot equilibrium of the duopoly model. In the case of duopoly there are only two firms F_1 and F_2 on the market in the same industry, with output q_1 and q_2 , respectively.

According to the generalized model (6), Cournot-Puu duopoly model is as follows (see also [7]):

$$q_{1}(t+1) = \sqrt{\frac{q_{2}(t)}{c_{1}}} - q_{2}(t),$$

$$q_{2}(t+1) = \sqrt{\frac{q_{1}(t)}{c_{2}}} - q_{1}(t).$$
(24)

Functions $q_1(t+1)$ and $q_2(t+1)$ with parameter values $c_1 = 1, c_2 = 6,25$ and initial conditions $q_1(0) = q_2(0) = 0,01$ have the form as shown in Fig. 1.



Fig. 1. The reaction functions of firms F_1 and F_2

Nontrivial equilibrium point of the system (24) – Cournot equilibrium (Nash equilibrium) – is a point of intersection of the reaction curves and according to the expression (7), has the value:

$$q_1^* = \frac{c_2}{(c_1 + c_2)^2}, \quad q_2^* = \frac{c_1}{(c_1 + c_2)^2}.$$
 (25)

Profit of the duopolists at the Cournot equilibrium is, respectively:

$$U_1^* = \frac{c_2^2}{\left(c_1 + c_2\right)^2}, \quad U_2^* = \frac{c_1^2}{\left(c_1 + c_2\right)^2}.$$
 (26)

Let us investigate the stability of the equilibrium point (25). We linearize the system (24) near the equilibrium point (25), as it was done for a generalized model in the preceding paragraph, and we obtain the Jacobi matrix:

$$J = \begin{pmatrix} 0 & \frac{c_2 - c_1}{2c_1} \\ \frac{c_1 - c_2}{2c_2} & 0 \end{pmatrix}.$$
 (27)

The eigenvalues of the matrix Jacobi J of the linearized system are the solutions of the characteristic polynomial:

$$\lambda^2 + a_1 \lambda + a_2 = \lambda^2 - tr J \lambda + \det J = 0, \qquad (28)$$

$$a_{1} = -trJ = 0,$$

$$a_{2} = \det J = \begin{vmatrix} 0 & \frac{c_{2} - c_{1}}{2c_{1}} \\ \frac{c_{1} - c_{2}}{2c_{2}} & 0 \end{vmatrix} = -\frac{(c_{2} - c_{1})(c_{1} - c_{2})}{4c_{1}c_{2}} = \frac{(c_{2} - c_{1})^{2}}{4c_{1}c_{2}}.$$
(29)

Equilibrium point (q_1^*, q_2^*) is asymptotically stable if for all the eigenvalues λ of the Jacobi matrix *J* condition (19) holds. Routh-Hurwitz procedure for n = 2 is as follows:

We construct the parameters (20):

$$b_{0} = 1 + a_{1} + a_{2},$$

$$b_{1} = 2 - 2a_{2},$$

$$b_{2} = 1 - a_{1} + a_{2}.$$
(30)

Then we construct a matrix:

$$\begin{pmatrix} b_1 & 0\\ b_0 & b_2 \end{pmatrix}, \tag{31}$$

and its principal minors:

$$\Delta_1 = b_1,$$

$$\Delta_2 = \begin{vmatrix} b_1 & 0 \\ b_0 & b_2 \end{vmatrix}.$$
(32)

Classical conditions of asymptotic stability are:

$$b_0 > 0, \quad \Delta_1 > 0, \quad \Delta_2 > 0.$$
 (33)

It means that:

$$b_0 > 0, \quad b_1 > 0, \quad \Delta_2 = b_1 b_2 > 0,$$
 (34)

namely:

$$b_0 > 0, \quad b_1 > 0, \quad b_2 > 0.$$
 (35)

Conditions (35) according to the values of the parameters b_i , i = 0,1,2 (30) and the coefficients a_i , i = 1,2 (29) can be written as:

$$1 - trJ + \det J > 0,$$

$$2 - 2 \det J > 0,$$

$$1 - trJ + \det J > 0.$$
 (36)

Or:

$$det J > trJ - 1,$$

$$det J < 1,$$

$$det J > -trJ - 1.$$
(37)

Fig. 2. shows the domain of attraction (stability), which is the triangle *ABC* in the space of eigenvalues $\{a_1,a_2\}$ with vertices:

$$A(-2,1), B(2,1), C(0,-1).$$
 (38)

The sides of the triangle of stability are defined by the following straight lines, *the divergence boundary:*

$$1 + a_1 + a_2 = 0$$
 or det $J = trJ - 1$, (39)

the flip boundary,

$$1 - a_1 + a_2 = 0$$
 or det $J = -trJ - 1$, (40)

and the flutter boundary,

$$a_2 = 1$$
 or det $J = 1$. (41)



Fig. 2. Stable region

Obviously, in our case, the conditions det J > trJ - 1and det J > -trJ - 1 are satisfied (trJ = 0), loss of stability occurs when the absolute value of eigenvalues becomes equal to unity, i.e., when det J = 1 either $\frac{(c_2 - c_1)^2}{4c_1c_2} = 1$. Denote the ratio of marginal costs, $\frac{c_2}{c_1} = c_r$, then det $J = \frac{(c_2 - c_1)^2}{4c_1 - c_2} = \frac{(c_r - 1)^2}{4c_2}$.

Stability domain of Cournot equilibrium will be:

$$\frac{(c_r - 1)^2}{4c_r} < 1, (42)$$

or

$$c_r^2 - 6c_r + 1 < 0. (43)$$

Namely:

$$c_{r_1} < c_r < c_{r_2},$$
 (44)

where: $c_{r_1}, c_{r_2} > 0$ are the roots:

$$c_{r_{12}} = 3 \pm \sqrt{8},\tag{45}$$

of the quadratic equation:

$$c_r^2 - 6c_r + 1 = 0. (46)$$

Thus, the dynamic process is stable, if the value c_r falls inside the interval bounded by the obtained solution, i.e.:

$$3 - \sqrt{8} < c_r < 3 + \sqrt{8}. \tag{47}$$

Without loss of generality we will assume that $c_2 \ge c_1$ (i.e., $c_r \ge 1$), then we will obtain a narrowing of this interval:

$$1 \le c_r < 3 + \sqrt{8}.$$
 (49)

From the condition of inalienability output for both firms and properties of their reaction functions, we determined the entire range of values related marginal costs c_{v} [11]:

$$\frac{4}{25} \le c_r \le \frac{25}{4}.$$
 (50)

Taking into account the assumption that $c_r \ge 1$, we will have a range of values c_r

$$1 \le c_r \le \frac{25}{4}.\tag{51}$$

Thus, we have found that the equilibrium point is stable in the interval (see equation (49)):

$$1 \le c_r < 3 + \sqrt{8}.$$

So, the equilibrium point is unstable in the second part of the interval:

$$3 + \sqrt{8} \le c_r \le 25 \,/ \,4. \tag{52}$$

Limit cycles and chaos exist in the system at these values c_r . Bifurcation diagram for firms F_2 with output q_2 with respect to the ratio c_r of marginal costs is presented in Fig. 3.



Fig. 3. Bifurcation diagram of the firm F_2 with the production q_2

CONCLUSIONS

In this paper, we generalize Cournot-Puu duopoly model when there are N firms on the oligopolistic market. It is considered that each firm-oligopolist produces the same standard products, which it has to sell for the same price (established based on the size of the total production in the industry). In such conditions, each company in this market (through decision on its own output) can influence the total output, and thus its market price. In addition, each firm is characterized by a function of optimal reaction. This function describes the optimal output (one that maximizes profits) of one firm according to the decision on the output of other firms.

The model is a system of nonlinear equations that has both trivial and non-trivial equilibrium points. Nontrivial point of equilibrium is Cournot (Nash) equilibrium. In this type of equilibrium each firm makes a decision, which enables to maximize its profit, anticipating the same behavior of competitor. In oligopoly equilibrium occurs at a lower price, more products and less overall profit compared to pure monopoly. Given the first two parameters (lower price and more products), oligopoly can be considered the best option for a market economy than monopoly.

The process of investigating the stability of the Cournot equilibrium point in the case of oligopoly is a time-consuming task. It can be carried out using the Routh-Hurwitz procedure. The article presents the study of the stability of equilibrium point for the duopoly. The value of the system parameter $c_{,,}$ at which the equilibrium point is stable, is established.

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The method of phase trajectories in system diagnostics of economic protectability of industrial enterprise

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A b s t r a c t. The article demonstrates the applied use of the method of phase trajectories for refinement of results of system-complex diagnostics of economic protectability of industrial enterprise. System of a kind "expenses-risk" with absolute speed of changes of its constituent elements is chosen as the adjustable parameter. On the basis of real dynamics of the specified parameters of the system there was revealed an interrelation with current protectability of entrepreneurial activity of business entity that gives an opportunity to make definitely right decision on the prognostic fluctuation of diagnosed his level of economic protectability in the short term.

Key words: the method of phase trajectories, diagnostics, economic protectability, expenses, risk, enterprise.

INTRODUCTION

Unfavorable market conditions of management that are prevailing at the current moment in the post-crisis period at most industrial enterprises of different countries of the world, aggravated the main problem of the present day - the search and implementation of optimal methods of diagnostics, assessment and control of the condition of current protective functions of leading production and economic structures in order to accelerate the adoption towards them of effective decisions on stabilization of the situation that has emerged. In this regard, we more and more need to clarify the system diagnostics of their condition of economic protectability that can combine both system-complex and structurally functional diagnostics. As system-complex diagnostics of economic protectability of enterprise is not necessarily the quantitative diagnostics of the condition of protectability of financialeconomic and production activity of business entity from the consequences of the actions of destabilizing factors of external and internal environments, but can be only qualitative, that is manifested through weighed check of implementation or non-implementation of system of criteria or principles of integrated economic protection

and is not always thorough in terms of profound functional analysis of all economic potential of enterprise on the basis of entered check indices-indicators, this kind of diagnostics needs obligatory refinement of the results through applied use of a number of economic and mathematical methods with a prevalence of the method of phase trajectories to confirm the objectivity of condition of protectability of enterprise in consequence of the dynamics of the value of expenses of different categories in combination with the value of allowed financial risk.

ANALYTICAL INSTRUMENTS

In general the condition of economic protectability of industrial enterprise is an integrated value that reflects the level of protection and simultaneously of condition of its competitiveness, liquidity, solvency, and creditworthiness fixing a performance of properties of efficiency, reliability, flexibility, capacity, stability and sustainability that are correlated by systematic and nonsystematic kinds of risks of arrival of threats, the total magnitude of which characterizes the quantitative measurement of possible deviations from expected result - permissible level of economic protection on the basis of conformity of performance of above mentioned properties of business entity considering controlled and uncontrolled factors that act continuously on the part of the main spheres of activity of enterprise. In its turn, the condition of economic protectability is correlated with the satisfactory or unsatisfactory financial condition of enterprise that is reflected in the degree or level of its economic protection.

Category "economic protectability", being dynamic in time, needs necessary diagnostics, that is the elaboration of the system of appraisal measures aimed at determination of the value of deviation of the fixed current functional protection of enterprise from the permitted level of the general condition of economic security first of all to maintain its normal continued existence.

Many scholars such as O. Dobykina, A. Herasymov, O. Hetman, L. Ivanets, S. Kasyanyuk, A. Kiriyenko, T. Kostenko, L. Kostyrko, O. Kuzmin, V. Luk'yanova, A. Maryuta, O. Melnyk, O. Oleksyk, V. Ryzhykov, V. Shapoval, H. Shvydanenko, I. Sokyrynska, Yu. Tolcheyev, V. Tszunov, A. Voronkova, O. Yelisieyeva, N. Yevdokymova, T. Zahorna, et al. [1, 7-21] were engaged in the issues of diagnostics of broad direction in the system of assessment of entrepreneurial activity. Each of the authors individually applied the appropriate mechanism or system of diagnostics for a current assessment of economic phenomena in the general system of functioning of enterprise having suggested diagnostics of bankruptcy, diagnostics of financial and business condition, diagnostics of financial and economic sustainability, diagnostics of economic (production) potential, diagnostics of competitiveness, diagnostics of creditworthiness, diagnostics of the market value of the property, diagnostics of antirecessionary management, diagnostics of management of production and economic systems, diagnostics of financial and economic activity of enterprise both in general and in the system of process-structured management, diagnostics of risks and economic security and so on. However, no one of them applied to the constricted category such as "economic protectability" the process of recognition of its quantitative value through refinement of its measurement, involving application of economic and mathematical methods.

SOURCE MATERIALS AND METHODS

Further development of market relations at the present stage increases the responsibility and independence of strategically important enterprises and of other market entities in the preparation and acceptance of administrative decisions, efficiency and economic security of which depends on comprehensiveness and objectivity of diagnostic assessment of their financial condition, in estimation of investors that are interested in profit earning and in an acceptable riskiness of investing their money in enterprise, in the relationship with creditors and suppliers who want to be convinced of the solvency of enterprise. Since the essence of market economy lies in the fact that all entities are free in their economic activity and should act at their discretion, on the basis of present conditions, the set rules and market regulators, such as interest rates, prices, taxes, customs tariffs, the amount of expenses, the magnitude of risk etcetera, that are formed according to the results of competition of producers, sellers, buyers and consumers and should look for any innovative approaches to intensify and rationalize their activity for further survival in the market and diagnosing in the higher level perspective of their economic security.

Selection of effective innovative solutions at industrial enterprise can be long-term and, therefore, impossible without comprehensive dynamic analysis of complex interconnected factors, determination and comparative estimation of possible alternatives and admissible plans of action for a given business entity. In this connection, in practice, diagnosed value of allowed level of economic protectability plays an important role for assessment of procedures of acceptance or non-acceptance of certain management decisions at an enterprise. It can be periodically subjected to recommended narrowly differentiated control with an application of variety of economic and mathematical methods that give an opportunity with the largest absolute precision in time to estimate the final financial and economic result of enterprise regarding the condition of implementation at it of such main properties as economic stability, independence, solvency, profitability, etc. It generally affects the completeness of correctness of urgent management decision making and holistically integrates objective procedure of diagnostics of the condition of economic protectability of enterprise.

Majority of elaborations concerning this problem are based on such economic and mathematical toolkit that consists of six basic stages: 1. Determination of problem situation of enterprise that currently has the most significant effect on the change of condition of its economic protectability under market conditions, and building of its formalized description. 2. Development of economic and mathematical model concerning the problem. 3. Selection of method and performance of calculations in a simulated situation. 4. Preparation of output information and simulation on real data. 5. Search for alternative variants and selection of the optimal one. 6. Adoption of an innovative approach concerning this problem with the use of economic and mathematical modeling [5].

Although these stages are reduced to six major ones, in real conditions their quality content can be changed. It especially concerns the third stage with the desirable conceptual combination of several economic and mathematical methods, namely the stage of selection of the method and performance of calculations in simulated situations that promotes building of a more accurate system of management according to components of condition of economic protectability of business entity, primarily affected by more factors from the external environment of enterprise. First of all it is a condition of financial and credit and investment activity of business entity, which, before all affects the diagnostics of condition of its economic protection, taking into account financial risks and elements of the losses.

In this regard, there is a need for simulation search for data for the investigated enterprise that would directly influence its financial stability and would allow to additionally conduct in-depth estimation of its key economic parameters such as: expenses, risk, loan size, expected income, the probability of successful realization of the investment project that can be the basis for innovative approaches of system-complex diagnostics of its level of economic protectability.

Experience shows that for the visual analysis of the dynamics of financial-economic activity and its impact

on the diagnosed value of the condition of economic protectability of production and business entity, it is best to use a graphical method - the method of phase trajectories. This method is based on the image of such changes in the form of the trajectory of motion of the point (of selected financial and economic parameter) that reflects it in the phase space [2, 3].

If a system of second order is chosen (dependence only between two parameters, for example the size of expenses of enterprise on time interval or dependence of expenses and risk of appropriate business entity), this movement will be provided on the phase plane. It is recommended to take an adjustable parameter expenses-risk (y) and speed (or value) of their changes (Δy) at enterprise [2, 4] as axis of coordinates. Weighed conclusions about entrepreneurial activity of production and economic structure in general can be done by the character of possible changes of parameters of the system.

During various economic processes that take place at the industrial enterprise which directly or indirectly affect the condition of its economic protectability, a point with specified coordinates $(y, \Delta y)$, when moving on phase plane will define the phase trajectory. A complex of phase trajectories that reflect dynamic properties of the system is called the phase portrait of the system. The method of isoclines is most frequently used for their construction [6]. The more times the trajectory crosses the x-axis in the area of the II and III quadrant of the coordinate system, the less stable is the condition of enterprise considered to be, first of all on the part of the control of the level of expenses if actual expenses exceed the planned ones.

Let us compare the planned expenses of the investigated enterprise regarding execution of works and their change with the actual service provided or volume of sold production displayed under continuous linear part. The output value V will be the risk of non-reimbursement of expenses of business entity. Level of expenses is monitored, as a rule, by the planning department of enterprise that adjusts the rate of change of the size of the actual expenses in comparison with the planned ones. The value of the existing level is compared with the set one and the risk is assessed according to the sign of this in coordination.

The transfer function of the linear part of the system, according to [6], has the form:

$$W(p) = \frac{k}{p \times (T_p + 1)},\tag{1}$$

where: k - is a constant, equal to 1 if there is the signal about the study of the economic system of enterprise and otherwise -0, T - the specific weight of expenses of enterprise; p - number of partners in this enterprise.

Output information is the fact that the financial risk that can be one of the identifiers of economic protectability of production and economic structure is constantly changing, and its value is determined by the sign of mismatch +1 or -1. Then the equation of the system in general form can be written as follows:

$$Ty'' + y' - k \operatorname{sgn}(x - y) = 0,$$
(2)

where: x and y – are coordinate values of regulated economic parameters that affect the condition of enterprise activity.

Having taken x = 0 and taking into account that sgn (-y) = -sgn(y), we get:

$$Ty'' + y' + kU \operatorname{sgn} y = 0.$$
(3)

In dimensionless coordinates they set T = 1, k = 1and denote sgn y = -d and therefore, d = 1 at Dy < 0and d = -1 at Dy > 0.

Then
$$V' + V = \delta$$
, where: $y' = V$ or $\frac{dV}{dy} = \frac{\delta - V}{V}$. (4)

The equation of phase trajectories is received by integration of this equation provided that t = 0 and denoting $V_0 = \Delta y_0$:

$$y = y_0 + \Delta y_0 - V + \delta \ln \Delta y_0 - \delta, \tag{5}$$

where: y - is the actual value of expenses of enterprise; $y_0 - is$ the planned value of expenses of enterprise; $Dy_0 - is$ the change of expenses; V - is the risk; d - isthe value of the identifier +1 or -1.

If the value of identifier is set d = 1, the equation of the phase trajectory will look like:

$$y = y_0 + \Delta y_0 - V + \ln(1 - \Delta y_0).$$
(6)

If d = -1 the equation of the phase trajectory will look like:

$$y = y_0 + \Delta y_0 - V + \ln(1 + \Delta y_0).$$
(7)

Transition of trajectory from d = 1 to d = -1 on phase plane takes place on y-axis. Herewith a transition zone is formed, that reflects the change of values of the actual expenses of enterprise in comparison with the planned ones, respectively, located sequentially according to the growing tendency from the coordinate origin. There is also a change of signs on *V*-axis, respectively, clearly according to the change of values of d from +1 to -1 and vice versa.

RESULTS AND DISCUSSION

Let us consider economic-mathematical method of the phase trajectories on the basis of data on the dynamics of expenses as a result of a generalized financial and production activity of N-th industrial enterprise given in Table 1.

When studying the real industrial entity its business activity covers the results of expenses simultaneously as a result of operating, financing and investing activities.

Number of crossings of zones of I, IV quadrants characterizes positive dynamics of decrease of actual expenses as to planned values within acceptable risks. Number of crossings of zones II, III characterizes the negative dynamics of growth of actual expenses of enterprise as to planned values fixing the negative value of risks. If the amount of crossings of I and IV zones exceeds the number of crossings of II and III quadrants, the positive tendency of economic stability at enterprise prevails and thus business entity keeps under control all the actual expenses and even has reserve funds and can lend them the similar enterprises of certain sector acting now as a creditor. However, this does not always correspond to the dynamics of the expected increase of level of economic protectability of real industrial enterprise and only if its incomes of the reporting period exceed actual expenses (Table 1), moreover, in the next time

period this tendency not only persists but also has a corresponding predicted rate of growth of incomes according to a linear, logarithmic, exponential and polynomial trend dependencies at diagnosing absolute or at least normal financial sustainability of business entity.

When the correlation coefficient is 1, the value of total incomes and expenses of enterprise is connected with linear functional dependence. However, the presence of absolute financial sustainability of enterprise at the reporting date does not always give a full guarantee for a rather high level of economic protectability. In addition, having set the speed of resizing expenses at an industrial enterprise, the predicted value of risk can be achieved that will be important for saving the appropriate condition of economic protectability (Table 2).

Let us apply the method of phase trajectories to the control of dynamics of expenses of enterprise (Table 3).

Table 1. Control values of inspection of excess of total incomes over total expenses in the system of ensuring economic protectability of enterprise for years 2010-2011(thousand hrn)

Nº	Parameter name	Planned value	Actual value	Deviation of planned incomes from planned expenses (+,-)	Deviation of actual incomes from actual expenses (+,-)						
	Year 2010										
1.	Total incomes	173576	187274								
2.	Total expenses	169266	182949	4310	4325						
			The correlation	coefficient 1							
			Year 20	11							
1.	Total incomes	221265	250645								
2.	Total expenses	216247	244713	5018	5932						
	The correlation coefficient 1										

Table 2. Control of actual expenses of industrial enterprise in accordance with the implementation of the financial plan for years 2010-2011 (thousand hrn)

Nº	Name of kind of expenses	Plan	Actual	Deviation (+, -)	Percentage of implementation						
	Year 2010										
1.	Cost of sales (goods, works and services)	141269	154248	12979	109,19						
2.	Administrative expenses, Total	18538	18965	427	102,3						
3.	Including: Expenses connected with the use of official cars	371	328	-43	88,41						
4.	Expenses for consulting services	0	0	-	-						
5.	Expenses for insurance services	0	0	-	-						
6.	Expenses for auditing services	7	7	0	100						
7.	Other administrative expenses	18160	18630	470	102,59						
8.	Selling expenses	480	417	-63	86,88						
9.	Other operational expenses	5200	5225	25	100,48						
10.	Financial expenses	939	246	-693	26,2						

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11.	Losses from participation in capital	0	0	-	-
12.	Other expenses	665	547	-118	82,26
13.	Tax on profit on ordinary activity	2175	3301	1126	151,77
14.	Extraordinary expenses (uncompensated losses)	0	0	-	-
Total	expenses	169266	182949	13683	108,08
		Year 2011			
1.	Cost of sales (goods, works and services)	181104	205509	24405	113,48
2.	Administrative expenses, Total	23792	26264	2472	110,39
3.	Including: Expenses connected with the use of official cars	395	406	11	102,78
4.	Expenses for consulting services	0	0	-	-
5.	Expenses for insurance services	0	0	-	-
6.	Expenses for auditing services	7	7	0	100
7.	Other administrative expenses	23390	25851	2461	110,52
8.	Selling expenses	615	632	17	102,76
9.	Other operational expenses	6713	9274	2561	138,15
10.	Financial expenses	1100	459	-641	41,73
11.	Losses from participation in capital	0	0	-	-
12.	Other expenses	123	129	6	104,88
13.	Tax on profit on ordinary activity	2800	2446	-354	87,36
14.	Extraordinary expenses (uncompensated losses)	0	0	-	-
Total	expenses	216247	244713	28466	113,16

Table 3.	Practical	implementati	on of the n	nethod o	of phase	trajectories	in the	system	of control	of exp	penses	of ind	ustrial
enterprise f	for years 2	2010-2011											

N₂	Planned values of expenses ϕ_0 , thousand hrn	Actual values of expenses y, thousand hrn.	Setting of identifier d	Design formula for calculation of risk V						
Year 2010										
1. 141269 154248 $d = -1$ 154248 = 141269 + 12979 $-V_1 - \ln(1 + 12979) \rightarrow V_1 = -9,4\%$										
2.	18538	18965	d = -1	$18965 = 18538 + 427 - V_2 - \ln(1 + 427) \rightarrow V_2 = -6,1\%$						
3.	480	417	d = 1	$417 = 480 + (-36) - V_3 + \ln(1+36) \rightarrow V_3 = 4,2\%$						
4.	5200	5225	d = -1	$5225 = 5200 + 25 - V_4 - \ln(1 + 25) \rightarrow V_4 = -3,3\%$						
5.	939	246	d = 1	$246 = 939 + (-693) - V5 + \ln(1+693) \rightarrow V_5 = 6,5\%$						
6.	665	547	d = 1	$547 = 665 + (-118) - V_6 + \ln(1+118) \rightarrow V_6 = 4,8\%$						
7.	2175	3301	d = -1	$3301 = 2175 + 1126 - V_7 - \ln(1 + 1126) \rightarrow V_7 = -7,0\%$						
			The correlation co	pefficient 0,999927						
			Year	2011						
1.	181104	205509	d = - 1	$205509 = 181104 + 24405 - V1 - \ln(1 + 24405) \rightarrow V1 = -0,1\%$						
2.	23792	26264	d = - 1	$26264 = 23792 + 2472 - V2 - \ln(1+2472) \rightarrow V2 = -7,8\%$						
3.	615	632	d = - 1	$632 = 615 + 17 - V3 - \ln(1+17) \rightarrow V3 = -2,9\%$						
4.	6713	9274	d = - 1	$9274 = 6713 + 2561 - V4 - \ln(1 + 2561) \rightarrow V4 = -7,9\%$						

N⁰	Planned values of expenses ϕ_0 , thousand hrn	Actual values of expenses y, thousand hrn.	Setting of identifier d	Design formula for calculation of risk V						
	Year 2011									
5.	1100	459	d = 1	$459 = 1100 + (-641) - V5 + \ln(1+641) \rightarrow V5 = 6{,}5\%$						
6.	123	129	d = -1	$129 = 123 + 6 - V6 - \ln(1+6) \rightarrow V6 = -1,9\%$						
7.	2800	2446	d = 1	$2446 = 2800 + (-354) - V7 + \ln(1+354) \rightarrow V7 = 5,9\%$						
	The correlation coefficient 0,999937									

Graphical interpretation of the phase trajectories of the system expenses-risk at enterprise for the period of years 2010-2011, is shown in figures 1-2.

Number of crossings of I and IV quadrants (Figure 1) is less than the number of crossings of II and III quadrants (6 <8), meaning that enterprise could not reduce the number of planned expenses in the reporting period. However, as the total incomes still exceeded total expenses of the period, it did not negatively affect the process of ensuring economic protectability. Number of crossings of I and IV quadrants (Figure 2) is much lower than the number of crossings of II and III quadrants (4 <10), meaning that enterprise could not reduce the number of planned expenses in the reporting year 2011; there is a high probability of fall in level of economic protectability in relation to the previous year 2010, although still within the allowable values as total incomes exceeded total expenses of the period (Table 1). However, this can negatively affect the process of ensuring economic security in the case if business entity has



+y, actual

Fig. 1. Graphical interpretation of the method of phase trajectories (expenses - risk) for enterprise according to investigated data of year 2010



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+y, actual

Fig. 2. Graphical interpretation of the method of phase trajectories (expenses - risk) for enterprise according to investigated data of year 2011

outstanding debt on the credit line or overdraft at the end of the reporting period, if the enterprise is officially self-financing.

CONCLUSIONS

Analysis of the method of phase trajectories demonstrated the possible applied use for refinement of the results of the system-complex diagnostics of economic protectability of industrial enterprise as an economic phenomenon, which at the appropriate entity characterizes a certain property that is based on the degree of absence of consequences of threats of influence of destabilizing factors of internal and external environments on the economic potential, on the overall production and economic activity of enterprise engaged in financial, production and business activity, including both positive and negative dynamics of risk and current expenses which is accurately fixed graphically as a result of crossing of isoclines of all categories of quadrants of the coordinate axes.

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Design of intelligent decision support systems using ontological approach

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Abstract. Methods of developing and functioning of intelligent decision support systems based on precedents applying adaptive ontology that are part of intelligent agents are analyzed. Method of distance definition between precedent and current situation based on adaptive ontology is developed. Using mathematical tools of the dynamic programming for modelling of intelligent system functioning is considered. Simplifying the task model is proposed to weigh signs of ontology concepts. Examples of such problems for six processes concerning metal structures protection and maximizing their lifetime are presented.

Key words: intelligent decision support systems, adaptive ontology, intelligent agents, precedents, dynamic programming

INTRODUCTION

The technology of intelligent decision support systems (IDSS) is one of the most developed areas of artificial intelligence. Researches in this area are in the development of automated information systems used in the areas of human activities that require logical reasoning, high skills and experience.

Present level of development of IDSS is two-way development of intelligent agents (IA) [1, 2]:

- IA, based on Case-Based Reasoning, or CBR,

- Agency planning activities (searching the state space). The choice depends on the IA task. Output methods by precedents are effective when the main source of knowledge about the problem is experience, not theory, solutions are not unique to a particular situation, and can be used in other cases, the purpose of solving the problem is not guaranteed to get the correct solution, and best possible. Output is based on precedents, a method for building IDSS decision on this issue or situation for the consequences of finding analogies that are stored in the precedent. This precedent is called relevant. From a mathematical point of view among elements of the set precedents $Pr = Pr = \{Pr_1, Pr_2, ..., Pr_k\}$, Pr_k is a relevant precedent for which the distance to the current situation S is the smallest, i.e. :

$$\Pr_k = \arg\min d(\Pr_i, S).$$

IA planning activities should achieve the target state. First he must build a plan to achieve this state with all possible alternatives. The planning process is based on decomposition. The task of planning ZP contains of 3 components: the set of states "St", a set of actions "A", a set of target states "Goal" (state purpose), i.e.:

$$ZP = \langle St, A, Goal \rangle.$$

As can be seen for both classes of IDSS is required metrics. In the first case - for assess the relevance of precedents, in the second case - to assess the relevance of states. On way of determining this metric is directly dependent performance of IA. In our view this way should be based on clear and reasonable standard knowledge base. In the field of knowledge engineering, ontology has become such a standard [3]. Therefore, we proposed to build metrics using ontology.

In the ontology model O understand the triple form:

$$O = \langle C, R, F \rangle,$$

where: C - the notion, R - the ratio between the concepts, F - interpretation of the concepts and relationships (axioms). Axioms set limits of semantic concepts and relations.

THE MODEL OF ADAPTIVE ONTOLOGY

The effectiveness is considered of adaptation ontology knowledge basis to determine the features of the subject area incorporated in its structure elements and mechanisms to adapt by learning during the operation. One approach to implementing such mechanisms is an automatic weighing concepts Knowledge Base (KB) and semantic connections between them during learning. This takes on the role of factors important concepts and relationships [4-7]. Important factor concept (communication) - a numerical measure which characterizes the importance of certain concepts (communication) in a particular subject area and changes dynamically according to certain rules in service systems. Thus, we expand the notion of ontology by entering into a formal description of factors, important concepts and relations. Therefore, this ontology we define as the top five ones:

$$O = \langle C, R, F, W, L \rangle,$$

where: W - the importance of concepts C, L - the importance of relations R.

Ontology defined in this way will be called adaptive, i.e. one that adapts to domain by modifying the concepts and coefficients of importance of these concepts and relations between them. This ontology is unambiguously represented as a weighed conceptual graph (CG) [8, 9]. So we will build the metrics by using weighed CGs.

We propose to determine the distance between the annotations as a distance between the major concepts (weight center) of these annotations. The center of the CG weight is a concept, an average distance from which to other concepts is the least. Obviously, thus determined distance will depend on the way we determine the distance between two adjacent CG vertices. For this purpose it is proposed to determine the distance between adjacent vertices, as:

$$d_{ij} = \frac{Q}{L_{ij}\left(W_i + W_j\right)},\tag{1}$$

where: W_i and W_j are the coefficients of importance of vertices C_i and C_j respectively; L_{ij} is coefficient of importance of the relation between vertices; Q is constant which depends on the particular ontology.

Let us assume that $L_{ii} = \infty$, then $d_{ii} = 0$.

Then lets us find the weight centers of the conceptual graph. The vertices for which the average distance is the smallest:

$$\overline{d}_{i*} = \min \overline{d}_{i}.$$
 (2)

The average distance \overline{d}_i for the vertex C is calculated according to the formula:

$$\overline{d}_i = \frac{\sum\limits_{j=1, j \neq i}^n d_{ij}^*}{n-1},$$
(3)

where: *n* is a number of graph vertices; d_{ij}^* is the shortest path between vertices C_i and C_j is calculated using known algorithms, such as Bellman–Ford, Dijkstra, and Floyd–Warshall.

Then, according to its conceptual graphs, let us find the distance between the abstracts. Note that the proposed distance thus satisfies all three metric axioms.

Example. We will show the developed distance efficiency on the example of abstracts of scientific papers. Let us consider three abstracts of papers.

 The work is carried out in the direction of information technologies development focused on the natural language information processing. The author proposes a model for the problem: putting a language material in order with the help of the uniform standard, which is considered rather significant for the given class of technologies. It is one of the central problems concerning the development of the effective technologies for language information processing.

The corresponding conceptual graph of the first abstract is presented in Fig. 1.

2. The article presents the basic concepts on researching and solving the problem of automatic knowledge retrieval from text documents. Industrial system that solves the stated- above as well as one of its main application tasks are described.

The corresponding conceptual graph of the second abstract is presented in Fig. 2.

3. The paper deals with the problem of automated text consistency analysis. It is proposed to implement text consistency via text logic analysis with the involvement of the knowledge of application domain, natural language and normative base.

The corresponding conceptual graph of this abstract is presented in Fig. 3.



Fig. 1. Conceptual graph of the first abstract







5 - knowledge

6 - domain

7 - natural_language

8 - normative_base



The value of weights of concepts and relations is taken from the test ontology known as "computer sciences direction" for the subject area "artificial intelligence". Using formula (1) in which Q was accepted to be 100, we obtain the weighted graphs, shown in Fig. 4.





Fig. 4. The weighted graphs for three abstracts

Using Dijkstra's algorithm and making the appropriate calculations by formulas (2) and (3), we obtain that the weight centers of relevant graphs are:

 $\overline{d}^1 = \{11\} = \{\text{'technologies'}\}, \ \overline{d}^2 = \{4\} = \{\text{'system'}\},\$ $\overline{d}^3 = \{5\} = \{\text{'knowledge'}\}$

The 1st and the 2nd texts are easily linked using vertex 'natural_language' (the 5^{th} in the 1^{st} text and the 7^{th} in the 3^{rd} text). Then $d_{5,11}^1 = 0, 42; d_{5,7}^3 = 0, 23$. And the distance between the 1st and the 3rd texts equals 0.65.

$$d^{13} = 0,42 + 0,23 = 0,65.$$

The 2nd and the 3rd texts are easily linked using vertex 'knowledge' (the 7th in the 2nd text and the 5th in the 3rd text). Then $d_{4,7}^2 = 0,71$, which is the distance between the 2nd and 3rd texts, because 'knowledge' is the center of the 3rd weighted graph. So $\overline{d}^{23} = 0,71$.

Since in the first two texts there are no common vertices we use the 3rd text to calculate the distance between the 1st and the 2nd texts. Then:

$$\overline{d}^{12} = \overline{d}^{13} + \overline{d}^{23} = 0,65 + 0,71 = 1,36$$

Thus, the 1st and 3rd texts are the closest in content and the 1st and 2nd texts are the farthest in content.

We proposed a method for calculating the weights of classes:

1. Total weight W_i^i of ontology class is equal to its own weight Wo_{i}^{i} , weight of sub-classes Ws_{i}^{i} and adjacent classes Wn_i^{l} (classes that are related with this class with no IS-A link):

$$W_j^i = Wo_j^i + Ws_j^i + Wn_j^i, (4)$$

where: $Ws_j^i = \sum Wc_k^{i+1} \cdot L_{j,k}$ is weight k of sub-classes of the *j*-class of *i*-level, moreover, for a root class the *i*level equals 0, $Wc_k^{i+1} = Wo_k^{i+1} + Ws_k^{i+1}$ is weight of class C_k^{i+1} ; L_{ik} is weight of the relation between class C_i^i and C_k^{i+1} .

Calculation of certain components of the class total weight is shown in the diagram (Fig. 5).



Fig. 5. Calculation scheme of certain components of the class total weight

2. At the moment of introduction of the new sub-class to (i+1)-level it gets its own weight Wo_j^{i+1} , which is equal to half of its own weight of the higher *i*-level class:

$$Wo_{j}^{i+1} = \frac{1}{2}Wo_{j}^{i}.$$
 (5)

The weight of class Wc_j^i and all parent classes up to the root class increases by the value of the weight of newly created sub-class:

$$Wc_i^m = Wc_i^m + Wo_i^{i+1}, \forall m \le i.$$
(6)

3. When relation is established between the concepts k_1 and k_2 an edge appears between corresponding vertices of the graph ontology, and to the weight of adjacent classes Wn_1 the weight Wn_2 is added and vice versa – to Wn_2 the weight of new adjacent class Wn_1 is added, so:

$$Wn_j = \sum_k Wc_k \cdot L_{j,k}.$$
 (7)

Re-establishing of relations leads to the appearance of multiple edges in the graph.

- Multiplicity of edges represents the frequency of appearance of a V pair of semantically related concepts
 L_{i+1} = V · L_i. After recalculation multiple edges do
 not increase the vertex valence.
- 5. Weight of ontology instance equals to the total weight of appropriate class.

So, the model of the ontology allows us to calculate the weight coefficients of their components in the process of their insertion, removal and use during system exploitation, thus realizing the mechanism of adaptation to the user domain [10].

FUNCTIONING OF INTELLIGENT AGENTS IN STATE SPACE ON BASED ADAPTIVE ONTOLOGY

Let the IA must decide solution for protection structures of metal from corrosion. Structures of metal is in some state, which called the initial state St(0). This state is characterized by a set of attributes $X = \{x_1, ..., x_n\}$ (as example for pipeline it may be - lifetime, the diameter of the pipe, material for realizing processing, etc. The values which take these signs $z_i = z(x_i), x_i \in X$ define the value function of utility f = f(Z), $Z = (z_1, ..., z_n)$ this structures of metal. Obviously, that not all signs have the same effect on the value f. Therefore it is appropriate to consider a subset of attributes $X_W \subset X$ where W is the weight of importance of attributes (as example for pipeline it may be – lifetime). Obviously, that the values of attributes are interdependent. The goal of IA is processing structures of metal, that is put it in some state (call it the target state Goal), for getting maximum value f.

From now we will consider that the state of goal is single. If several states of goal are present, it means that goal can be written as a disjunction of these states. Achieving this state is the solution of some subtasks therefore assumption about singling of target state is normal.

Action A consists of four parts: the name of action, the list of parameters, preconditions and results. Plan is defined as a tuple of four elements – <set of actions, set of limitation of order, set of causal relations, the set of open preconditions> [2, 11, 12]. We propose to use graphs model of diagram of UML (Unified Modeling Language) [13] for врахування decomposition and / or dependence between states and transitions, for showing alternatives achieve the target states. Example of this oriented graph with target state *Goal* is showing in Fig. 6.

Moreover, the essence of rational functioning IA is transition to the final state *Goal* with minimum expenditure of resources G (resources can be specified in the form of cash equivalent, man-hours, time, etc.), namely the correct allocation of resources for action. For determination values of attributes depending on the performed actions we will use the ontology O of materials science [3]. The resulting task will be formally written in the form:

$$P: St(0) \xrightarrow{G,O} Goal.$$
(8)

The dynamic programming (DP) [2] is most often used in the role of mathematical tools, that is allowing to plan multistep controlled processes , and processes which are developing in time. We will show that our task of rational planning of IDS can be reduced to DP.

The effectiveness U of the whole process P can be presented as the sum of efficiencies $U_j(j = \overline{1, n})$. of separate steps, that is: $U = \sum_{j=1}^{n} U_j$, entitled additive criterion. The adopting some decisions is relating with each stage (Step) of task, so-called stepper control $q_j(j = \overline{1, n})$, that is passing as efficiency of this stage and the whole process. Solving the task of dynamic programming is lying in finding a management $Q = (q_1, q_2, ..., q_n)$ of the entire process, which is maximizing the overall effectiveness max $U = \sum_{j=1}^{n} U_j$. The optimal solution of this task is management Q^* that is consisting of a set of optimal turnbased managements $Q^* = (q_1^*, q_2^*, ..., q_n^*)$ and allows for the achievement of maximal effectiveness: $U^* = \max_{q \in Q} \{U(q)\}$.



Fig. 6. Example of diagram states of UML modeling behavior of intelligent agent

IDS should be able to assess the conditions and actions for selecting the necessary actions. It is easier to make with states in which structures of metal already was presented. It is more difficult to estimate future states. The everistic functions or meta knowledge that are storing in the ontology of materials science are using for estimating. Therefore, first we will consider the estimation of pasted states, then action, and finally a combination of them, that is leading to a new state [14-15].

Let v(St(i)) is valuation of state St(i). State of goal *Goal* is defining by necessity of some set of attributes X_w to reach some values of $z(x, Goal) \ \forall x \in X_w$. Any state St(i) is given by its set of attributes Y_i , which are taking the values $z(y, St(i)) \ \forall y \in Y_i$.

For evaluation state St(i) set of attributes and their values of state St(i) need to display ψ into set of attributes and values of state *Goal*. Clearly, this displaying is using a basis of knowledge of software, namely bonus pluging of ontology Semantic Web Rule Language:

$$\psi: Y_i \xrightarrow{O} X. \tag{9}$$

Then the estimation of state v(St(i)) is calculated:

$$v(St(i)) = d(St(i), Goal) =$$

= $\sum_{x \in X_{W}} \varphi(z(\psi(y), St(i)), z(x, Goal)),$ (10)

where: X_w is a set of attributes with the largest weights W in ontology, φ is metric (as example Euclidean, Manhattan, Lemmings, Zhuravleva, etc., the choice of which is depending on the type of attributes of the problem (quantitative, qualitative, mixed) [16, 17].

In our investigation for selecting the actions of IA we will rely on rational adopting decision by system, namely on the correct allocation of available resources *G* on actions for the achievement of maximum efficiency *U*. Therefore, we will assume that every action a_{ij} is uniquely determined by the expenditure of resources g_{ij}^k (cost of transition from state to state), where $k = 1, 2, ..., n_i$, n_i is the quantity of alternatives a_k for doing transition a_{ij} . Therefore, further action will be marked by three indexes a_{ij}^k : transition from state St(i) in state St(j), with using an alternative a_k . For example, three alternatives: mechanical, chemical and thermal withdrawal can be used for removing the protective coating from the surface of the pipeline.

Each alternative is characterized by the cost of resources and term of the exploiting. Information about alternatives and the costs of resources, prize from transition of state (time of exploitation, etc.) is also stored in the ontology. Obviously, that new alternatives can be appearing, therefore it is necessary to monitor new information in scientific journals. The task of automatic replenishment of the ontology which is based on the analysis of scientific texts is describing in [5]. Effectiveness of action a_{ii}^{k} is the meaning of function which is dependent on an assessment of the transition to a new state v(St(j)), the cost of resources g_{ij}^k and the prize $f(Z_j):U(a_{ij}^k) = \delta(St(j),$ g_{ii}^k , $f(Z_i)$ where Z_i is the importance of attributes in the state St(j). Then the action of IDS is determining the management Q. Thus, the task (9) is reduced to the task of dynamic programming.

We will consider the example of adopting decisions by IA for modernizing the pipeline (see Fig. 7). Initial state: unprocessed. The final state (state of goal): processed:



Fig. 7. The general task of modernization the pipeline

The task is divided into three subtasks (preparation, coating, protection), the first of which is divided into 4 subtasks (disclosure of tube surface, removal of protective coating, decreasing, priming) as showing in Fig. 8. The alternative solutions are used for solving of each subtasks. So for subtasks of removal of protective coating, one of three alternatives: mechanical, chemical or thermal can be used. All this information is stored in an appropriate ontology (ontology of PO modernizing the oil and gas



Fig. 8. Processing task decomposition "elaboration"

pipelines have been in the process of elaboration in the laboratory of system analysis of scientific and technical information of Physical-Mechanical Institute of Ukrainian NAN G.V. Karpenko) [18-20].

Thus in general it is necessary to successively solve the six subtasks P_1, P_2, \dots, P_6 . For each task it is necessary to choose the method of solution (alternatives) [21]. If *G* is the available resource, r_e is the desired lifetime of the pipeline, then rationality of adopting decisions will consist in:

$$U = \sum_{i=0}^{N-1} U(a_{ij}^k) \rightarrow \max,$$

$$r \ge r_e,$$

$$\sum_{i=0}^{N-1} g_{ij}^k \le G.$$
(11)

Let the resource consist of 6 units: G = 6. Example of possible costs g and prizes U depending on the number of the process and alternatives are presented in Table 1.

Using the method of functional equations (2), which is designed for solving tasks of dynamic programming, we will obtain the optimal path, which is shown in Fig. 9.

Table	1. Table of	1. Table of costs and prizes							
	Naaltarn	Drogons 1	Drocoss 2						

№ altern.	Process 1		Process 2		Process 3		Process 4		Process 5		Process 6	
	Cost	Prize										
<i>a</i> ₁	0	5	0	8	0	3	0	4	0	2	0	3
<i>a</i> ₂	1	7	1	9	1	4	1	7	1	3	1	7
<i>a</i> ₃	2	8	2	12	-	-	-	-	2	6	-	-



Fig. 9. The process of solving the task of dynamic programming
The optimal plan of distribution of resources among the processes of processing the pipeline is showing in Table 2. Revenue from the operation of the pipeline will be 40 units.

Process	№ alternatives	Resources	Prize	
Process 1	1	0	5	
Process 2	3	2	12	
Process 3	1	0	3	
Process 4	2	1	7	
Process 5	3	2	6	
Process 6	2	1	7	

Table 2. Table of adopting by IDS decisions

CONCLUSIONS

The mathematical model of intelligent decision support systems, depends on the class of problems. All these models use metric for finding the relevant precedents or relevance of states. To construct such metrics ontology is used. For this purpose, generally to three elements of procession, which sets the ontology (set of concepts, relationships and their interpretation) we add two scalar values (the importance of concepts and relations) which are used to calculate the necessary distances.

Consider the use of mathematical tools of dynamic programming for solving the task of planning protection of metal from corrosion which is based on intellectual diagnostic systems. The core of knowledge basis is material ontology. For determining the effectiveness of intellectual diagnostic system's work we proposed to use rules that are set in ontology. Significance of characteristics from ontology of concepts for simplifying the model of tasks was set. The example of functioning of intellectual diagnostic system, which is based on the modernization of pipeline in order to maximize its lifetime is shown there.

Consider the four classes of problems. The list of tasks is included in these classes. The examples of the functioning of some intelligent systems is based on the developed models.

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Metrology risk of product quality at manufacturing stage

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A b s t r a c t. The article shows that an effective tool of minimization of losses from non-probability measurements at the stage of production is the use of risk management system. The expediency of evaluation of metrology risk of quality of products on the manufacturing stage in a kind of the generalized relative index - index of metrology risk - was grounded. This index must represent the loss of efficiency and effectiveness of the system of production metrology provision. The expressions for the estimation of the metrological risk index were offered and methodology of ranking production by the level of metrology risk was developed.

Key words: metrology risk, quality, metrology provision, efficiency, effectiveness.

INTRODUCTION

The modern stage of development of society is characterized by growth of requirements as to quality of products. Globalization processes are instrumental in the operative reacting of world market on the changing of quality of products. Only high-quality products become competitive. The basic requirement in the process of creation of products of necessary quality is minimization of charges on their production. It promotes requirement of providing the optimum interrelation between quality and charges on production. Modern changes in approaching the organization of production, large-scale introduction of quality control system to a great extent promote requirements of organization of metrology activity during production [1]. It predetermines the search of ways of upgrading and efficiency of measurement processes at the manufacturing stage of products and integration of them in the normative provision of products quality.

EXPEDIENCE OF INTRODUCTION OF METROLOGY RISK CONCEPT IN PRODUCTS QUALITY

Primary development of risk management took place in a financial bank sphere, however lately actuality of management risks grows in other spheres (management of enterprises risks, technological risks) [2-5]. The process of risk management engulfs the different aspects of work with a risk, from authentication and analysis of risk to the estimation of its admission and determination of potential possibilities of risk reduction by the choice, realization and control of the proper managers of actions. Currently, an especially significant question is management metrology risk, as by basic risks which determine the degree of controllability of technological processes, product quality control levels and, consequently, expenditure on its production are influenced [6, 7].

For the construction of effective control system of metrology risks providing the quality of products at the stage of manufacture it is necessary to define the concept of this risk. In dictionaries [8, 9], publications [10, 11] and normative documents [12, 13] determinations of risk are resulted for different industries of activity, where different maintenance is appropriated by a risk concept: probability of losses, possibility of failure to achieve the goal, deviation from the norm, measure of uncertainty of a combination of probability of occurrence and its consequences.

Consequently, there exist various ambiguities related to the disclosure of the nature of risk and related concepts. In general, the concept of risk describes the probability of occurrence of certain events in the future and the risk reflects the potential loss [9, 10].

At the stage of production adverse events decide on claiming worthless the products that are really suitable (producer risk) and a decision on the suitability of products which are actually useless (consumer risk) [14]. As acceptance of these decisions is carried out on the basis of results of measurements during quality control, metrology risk will be the determined probabilities of origin of risk of producer and risk of user as a result of inauthenticity of control. Thus, it is possible to define metrology risk at the manufacturing stage as probability of influence of measurement results on the decision about the suitability of products, and the measure of metrology risk can be losses of production resulting from inauthenticity of control.

However, taking into account complication of modern technological processes, it is hard to provide the adequate estimation of risks brought about by the metrology provision in quality control of products. It concerns both the determination of influence of metrology activity on the quality of products and the evaluation of quality loss levels caused by inauthenticity of control.

Therefore, for the increase of adequacy of evaluation of product quality metrology risks at the stage of manufacture it is expedient to analyze metrology provision as an organizationally difficult technical system integrated into the system of quality management.

RESEARCH ON THE PROVISION OF METROLOGY AS AN ELEMENT OF QUALITY CONTROL SYSTEM

A rational way of improving product quality at the level of individual enterprise is the introduction of quality control system in accordance with the standard requirements [15]. Traditionally, measurement efficiency in the process of products manufacturing is determined by correlation of expenditures on the provision of necessary measurement exactness and losses from measurement inaccuracy [16]. The problem of measurement efficiency increase at the stage of products manufacture is not new, however no synonymous decision has been found as yet. It is predefined mainly by the complication of the processes of realization of product quality metrology provision, involving a lot of normative, legal, organizational, technical and scientific methodical factors which determine the terms of achievement of unity and necessary exactness of measuring at the stage of manufacture. As the efficiency of industrial measurement is largely determined by the efficiency of metrology provision, there is a necessity of the use of modern instruments of minimization of losses in an enterprise from the inauthenticity of quality control of production processes.

Considerable practical interest is presented by researches of the managements in development of the risk control systems integrated in the regular quality control system model of their enterprise [17].

Basic tasks of the metrology provision for products quality at the stage of manufacture can be presented in the following way (Figure 1).

Such a way of organization of metrology activity in an enterprise allows: firstly, to set rational connection of the metrology provision system in an enterprise with the requirements of the state system of measurements unity provision; secondly, to effectively integrate the elements of metrology provision in the quality control system.

For authentication of the metrology provision elements in the manufacturing process it is expedient to recognize such basic features of the system as:

1) metrology activity is an organizational constituent of co-operation of metrology service with production in view of metrology provision,

2) provision is a process of establishment and observance of metrology requirements and rules during the manufacturing of products,

3) quality and efficiency of measuring is the state of optimum combination of quality and efficiency of measuring is needed, that is predefined requirements of production.



Fig. 1. A task of the metrology provision for products quality at the stage of manufacture

Presentation of the metrology provision system of the offered kind will allow to systematize requirements of the measurement processes and rationally implement the provision risk management for the minimization of products quality losses at the manufacturing stage.

DETERMINATION OF METROLOGY RISK AND INDEXES FOR ITS EVALUATION

During a long time the analysis of metrology risks at the stage of production was limited to the probabilistic analysis of risks of a producer and user [18] and consisted in the determination of dependences between the estimations of losses of production from the indicated risks for a certain period of time and estimation of average exactness of control. Such approach gave the generalized

descriptions of metrology risk and was not instrumental in creation of the effective systems of their operative management. With applying of control in industry, the system of quality control [15] and the measurement system [18] have become new terms for the effective management of production risk, and in particular, metrology risk.

In obedience to modern approach, an analysis of risk is the systematic use of information for determination of sources of risk and their quantitative estimations [19]. At present there are no generally accepted methods of metrological risk evaluation. Taking into account the necessity of presentation of metrology risk for the type of the generalized relative index which can be integrated in the modern systems of management of quality, it is expedient to estimate a metrology risk in the type of the index of metrology risk of quality of products at the manufacturing stage.

Integration of the metrology provision system of production in the systems of quality management allows to analyze the metrology risk of quality of products as risk of disparity of the system of the metrology provision by the indexes of efficiency and effectiveness [20]. According to the methodology presented above, the evaluation of metrological support in terms of efficiency and effectiveness, metrological risk index should include two components: an index of metrology risk of loss of effectiveness and index of metrology risk of loss of efficiency of the system of the metrology provision in the products quality at the stage of manufacturing.

Analytical expression for metrological evaluation index of products quality loss can be presented in the form:

$$I_M = \sqrt{I_R \cdot I_E},\tag{1}$$

where: I_R is an index of loss of effectiveness; I_E is an index of loss of efficiency.

The index of loss of effectiveness is determined as a relation of difference of complex index of effectiveness in the present moment of control E_R^1 to effectiveness in the previous moment of control E_R^0 to the complex index of effectiveness in previous moment of control E_R^0 to effectiveness:

$$I_{R} = \frac{E_{R}^{0} - E_{R}^{1}}{E_{R}^{0}}.$$
 (2)

The index of loss of efficiency is determined as a relation of difference of values of the generalized indexes of quality of the system of the metrology provision in the present moment of evaluation G^1 to the previous moment of evaluation G^0 to the generalized index in the previous moment of control G^0 :

$$I_{E} = \frac{G^{0} - G^{1}}{G^{0}}.$$
 (3)

With the purpose of increase of products quality control system's efficiency at the manufacturing stage, it is expedient to carry out the appropriation of production category by the level of index of metrology risk and perform the recommended steps to minimize it.

Table 1. Appropriations of production category according to the level of metrology risk index and measures taken towards its minimization.

Value of index of metrology risk	A category of production according to metrology risk	Measures taken towards the minimization of metrology risks		
0,0 - 0,2A - is practical absence of metrology risk		Periodic monitoring of metrology risk		
0,2 - 0,4	B - is an insignificant metrology risk	An estimation of accordance of the system of the metrology providing is on the indexes of effectiveness		
0,4 - 0,6	C - is a middle metrology risk	An analysis of metrology risk is a that estimation of accordance of the system of the metrology providing on the indexes of efficiency		
0,6 - 0,8 D - is a considerable metrology risk		Minimization of sources of metrology risk is an estimation of accordance of the system of the metrology provision with the indexes of efficiency and effectiveness		
0,80 - 1,00	F - is an impermissible metrology risk	Reformation of the system of the metrology provision and evaluation of its accordance influences the indexes of efficiency and effectiveness		

For an analysis and management of metrology risks it is necessary to carry out their authentication, determine measures for the decision of problems which they can cause and use, here, objective information. Analysis of metrological risk can be used by experts for enterprise decision in assessing the admissibility of these risks, as well as the choice of measures to reduce or eliminate the production loss from non- reliable quality control during its manufacture.

CONCLUSIONS

The primary purpose of evaluation of metrology risk is systematization of possible disparities which can arise at control of quality of products and conditioning for ranking of technological processes according to the level of products quality losses resulting from the inauthenticity of measuring.

Importance of the stage of metrology risk reduction consists in the necessity of the formalized ground for decision-making processes and planning of effective actions for minimization of metrology risk in the quality of products at the manufacturing stage. It is also necessary to organize the process of permanent control of level of metrology risk which will allow for an operational reaction to its changes and taking proper correcting action in time.

Introduction of control of the system by metrology risks production will be instrumental in the increase of efficiency of the industrial measurement systems and diminishing of expenditures on products quality provision. For effective application of control of the system of risk metrology in the quality of products at the stage of manufacturing, it is necessary to create a list of metrology risks indexes, and also proper normative provision for their grounded application in the control of the system quality.

The introduction of metrological risk level rankings will organize corrective actions to improve the system of quality losses due to the non- reliability of control of process parameters and quality of finished products. Together, this will increase the efficiency of corrective actions and consumer confidence in the results of quality control at the stage of manufacture process.

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Qualitative methods for research of transversal vibrations of semi-infinite cable under the action of nonlinear resistance forces

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Abstract. The aim of paper is to study the solution of the problem of nonlinear transverse vibrations of elastic elongated body under the force of resistance in unbounded domain. Such problems have applications in various technical systems - vibration of pipelines, railways, long bridges, electric lines, optical fibers. Unboundedness of the area creates more fundamental difficulties in the study of the problem. For the considered models of nonlinear oscillations have no general analytical techniques for determining the dynamic characteristics of the oscillatory process. Therefore it is suggested to use qualitative methods of the theory of nonlinear boundary value problems to obtain correct problem solution conditions (existence and uniqueness of the solution). In the paper conditions of the correctness of the solution of mathematical model for these nonlinear systems (sufficient conditions of the existence and uniqueness in the class of locally integrable functions) are obtained.

Methods of qualitative study of semi-infinite cable vibrations under the forces of resistance based on general principles of the theory of nonlinear boundary value problems - method of monotony and Galerkin method. Scientific novelty of the work lies in particular in the generalization of methods of studying nonlinear problems on a new class of oscillatory systems in unbounded domains, justifying the correctness of the solution with specified mathematical model, which has practical applications in real engineering oscillatory systems.

The technique allows not only for proving the correctness of the model solution, but also has an opportunity in its study to apply various approximate methods.

Key words: mathematical model, nonlinear vibrations, nonlinear boundary value problem, Galerkin method, method of monotony, unbounded domain.

INTRODUCTION. OVERVIEW OF THE MAIN RESULTS

Problems of studying dynamic processes in nonlinear oscillatory systems describing the transverse (longitudinal) vibrations with the movements of cargo by conveyor belt (cable) type are important problems of mechanics. Investigation of nonlinear oscillatory and wave phenomena in elastic rod structures under the action of various perturbations (power, inertial and kinematic) is one of the classic problems of structural mechanics. Revitalization of theoretical research in this direction is due to not only logic of the foundations of deformed systems dynamics of, but also the interests of a wide variety of practical applications in the construction and engineering.

It should be noted, that the problem of studying of the influence of system parameters (such as speed of belt movement) on vibrations, sufficiently investigated in the case of constant velocity and linear law of elastic material. Specified is due to the fact that such situations are modeled by linear partial differential equations [4, 11, 18]. Asymptotic methods of nonlinear mechanics allowed to explore a wide class of mechanical oscillation systems for the case of quasi-linear dependence of amplitude of oscillations from the resistance force [17, 23]. In the case of non-linear law of elastic material, essentially nonlinear dependence of amplitude of vibrations from the resistance forces and variable speed of belt (cable) movement, problem is associated with the principled mathematical difficulties because there are no general analytical methods for solving this class of problems. Therefore, there is no general techniques of evaluation of amplitude - frequency characteristics of the oscillatory process. On the other hand, qualitative methods of general theory of nonlinear boundary value problems allow for a wide class of oscillatory systems to obtain correct solution results of the problem (existence, uniqueness and continuous dependence on the initial data). The above technique allows to substantiate the correctness of the model solution and allows in further investigation to use various approximate methods. Thus, the problem of qualitative research methods for nonlinear systems is relevant.

This article focuses on the qualitative study of mathematical models of nonlinear oscillations of semi-infinite cable under the action of nonlinear resistance forces. Similar problems arise in various technical applications such as vibrations of the pipelines on (nonlinear) elastic soil, railways, long bridges, tightly stretched electric lines, optical fibers embedded in the nonlinear elastic body, etc. [5, 6, 10, 15, 16, 21, 22].

In case of essentially nonlinear dependence of the amplitude from resistance forces problem associated with the principled mathematical difficulties even for the case of oscilatory model studies in a bounded domain. This problem is generally solved only for a very narrow class of problems.

Unboundedness of domain creates additional fundamental problems.

Particular problem for nonlinear wave equations in a form:

$$\frac{\partial^2 u}{\partial t^2} - \alpha \frac{\partial^2 u}{\partial x^2} + \beta \left| u \right|^{\rho-2} u = f(x,t), \, \rho > 2,$$

 α , β - some functions (constants) in unbounded domains was considered in [3, 1, 9, 7, 2, 27, 18, 15, 13, 20]. At the same time limitation of elliptic operator coefficients are assumed. The results of existence and uniqueness of the solution of problems in unbounded domains in these works are obtained under the assumption of certain behavior of solution, initial data and of the right side of the equation at the infinity or without such assumptions. Currently qualitative results about the correctness of the solutions mentioned above mathematical models could be obtained only for a rather narrow class of problems in unbounded domains, because in unbounded domains we need to modify the methods of the general theory of nonlinear boundary value problems.

PROBLEM STATEMENT

The article presents qualitative research methodology of mathematical model for nonlinear oscillations of elastic semi-infinite cable under condition of linear (variable by spatial variable) elastic law and nonlinear resistance force. In its simplest formulation model is described by the mixed problem for the equation:

$$\frac{\partial^2 u(x,t)}{\partial t^2} - \frac{\partial}{\partial x} \left(a(x) \frac{\partial u(x,t)}{\partial x} \right) + g\left(x, \frac{\partial u(x,t)}{\partial t} \right) = f(x,t),$$
(1)

with initial conditions:

$$u(x,0) = u_0(x),$$
 (2)

$$\frac{\partial u(x,0)}{\partial t} = u_1(x),\tag{3}$$

and boundary conditions:

$$u(x,0) = u_0(x),$$
 (4)

in unbounded domain $Q = (0, +\infty) \times (0, T), 0 < T < +\infty$. Further in this paper we denote $Q_{R,\tau} = (0, R) \times (0, \tau), Q_{\tau} = (0, +\infty) \times (0, \tau)$ for arbitrary $R > 0, \tau \in (0, T]$. We will use the following Sobolev space of functions:

$$H_0^1(0, R) = \left\{ u \in H^1(0, R) : u \right|_{x=0} =$$

= $u \Big|_{x=R} = 0 \right\}, \quad \left\| u \right\|_{H_0^1(0, R)}^2 = \int_0^R \left(\frac{\partial u}{\partial x} \right)^2 dx,$
 $H_{0, loc}^1(0, +\infty) = \left\{ u \in H^1(0, R) \text{ for arbitrary } R > 0, \quad u(0, t) = 0 \right\},$
 $L_{loc}(\overline{Q}) = \left\{ u \in L^r(Q_{R, T}) \text{ for arbitrary } R > 0 \right\},$
 $r \in (1, +\infty).$

The generalized solution of the problem we will call a function that satisfies conditions (1), (2), (4) and the integral identity:

$$\int_{Q_{\tau}} \left[-\frac{\partial u}{\partial t} \frac{\partial v}{\partial t} + a(x) \frac{\partial u}{\partial x} \frac{\partial v}{\partial x} \right] dx dt + \\ + \int_{Q_{\tau}} \left[\left| \frac{\partial u}{\partial t} \right|^{p-2} \frac{\partial u}{\partial t} v - f v \right] + \\ + \int_{0}^{+\infty} \frac{\partial u}{\partial t} (x, \tau) v(x, \tau) dx - \\ - \int_{0}^{+\infty} u_{1}(x) v(x, 0) dx = 0.$$
(5)

For arbitrary $\tau \in (0, T]$ and for an arbitrary function with limited carrier such that:

$$\begin{aligned} v \in L^{2}((0,T); H^{1}_{0,loc}(0,+\infty) \cap L^{p}_{loc}(\overline{Q}), \\ & \frac{\partial v}{\partial t} \in L^{2}_{loc}(\overline{Q}). \end{aligned}$$

Concerning the coefficients of the right side of the equation (1) and the initial data let's assume the fulfillment of following conditions.

(I) Function a(x) belongs to the space $C([0,+\infty))$, $a(x) \ge a_0, a_0 = const > 0$ for all $x \in ([0,+\infty); |a(x)| \le M(1+x^{\alpha})$ for $x \to +\infty$, where M > 0, $0 \le \alpha < 1 - \frac{p-2}{2p}$.

Remark. In the above relation is taken into account, that the modulus of elasticity can grow at sufficiently large *x* very slow (slower than the linear law) or stays constant.

(II) Function $g(x, \xi)$ - measurable by x and continuous by ξ moreover for arbitrary ξ , $s \in R$ and almost all $x \in (0, +\infty)$ we will obtain:

$$|g(x,\xi)| \le g_1 |\xi|^{p-1}, \quad p > 2,$$

$$g_1 = const > 0,$$

$$(g(x,\xi) - g(x,s))(\xi - s) \ge g_0 |\xi - s|^p,$$

$$g_0 = const > 0,$$

(III) $f \in L^q_{loc}(\overline{Q}), \quad \frac{1}{p} + \frac{1}{q} = 1.$
(IV) $u_c \in H^1_{1,c}, (0, +\infty), \quad u_c \in L^2_{c}, (0, +\infty)$

The aim of proposed work is to study the problem (1) - (4) for second order nonlinear wave equation, which in particular includes the equation of forced oscillations of the rod in the medium of resistance [14, p. 234] and obtain conditions for the correctness of solution of the mathematical model - sufficient conditions for existence and uniqueness of solution in the class of locally integrable functions.

The main result of this paper: if the mathematical model of oscillating process is described by problem (2) - (4) for equation (1), then under the conditions (I), (II), (III),

(IV) exist unique generalized solution of problem (1) - (4) for which:

$$u \in C([0,T]; H^1_{0,loc}(0,+\infty),$$

$$\frac{\partial u}{\partial t} \in C([0,T]; L^2_{loc}(0,+\infty) \cap L^p_{loc}(\overline{Q}).$$
(6)

METHODS OF OBTAINING RESULTS

Let u^1 , u^2 - generalized solutions of problem (1) - (4) and problem that differs from (1) - (4) by the fact that in the right side of (1) force *f* is replaced by $\overline{f} \in L^q_{loc}(\overline{Q})$ respectively. Then for arbitrary τ, R, R_0 such, that $0 < R_0 < R$, $\tau \in (0,T]$, we can obtain the following evaluation:

$$\int_{0}^{R_{0}} \left(\frac{\partial u^{1}(x,\tau)}{\partial t} - \frac{\partial u^{2}(x,\tau)}{\partial t} \right)^{2} dx + \\ + C_{1} \int_{0}^{R_{0}} \left(\frac{\partial u^{1}(x,\tau)}{\partial x} - \frac{\partial u^{2}(x,\tau)}{\partial x} \right)^{2} dx + \\ + C_{2} \int_{\mathcal{Q}_{R_{0},\tau}} \left| \frac{\partial u^{1}}{\partial t} - \frac{\partial u^{2}}{\partial t} \right|^{p} dx dt \leq \left(\frac{R}{R - R_{0}} \right)^{\beta} \times \\ \times \left\{ C_{3} R^{1 + (\alpha - 1)\frac{2p}{p - 2}} + C_{4} \int_{\mathcal{Q}_{R,\tau}} \left| f - \overline{f} \right|^{q} dx dt \right\},$$
(7)

where: $\beta > \frac{2p}{p-2}$ - arbitrary number; C_1, C_2, C_3, C_4

- positive constants that depend only from p, β .

Let's explain the inequality (7). Let $R > R0 > 0, \tau \in (0,T]$ - arbitrary numbers. We define the function φ as follows:

$$\begin{cases} \frac{R^2 - x^2}{R}, & x \le R, \\ 0, & x > R. \end{cases}$$

Directly convince ourselves that the evaluation of function φ holds:

Let u^1 , u^2 - generalized solutions of problem (1) - (4) and problem (1) - (4), where in the right side of equation (1) function f is replaced by $\overline{f} \in L^q_{loc}(\overline{Q})$. We set further $w = u^1 - u^2$ and follow the procedure of regularization described in [14 pp. 238 - 239]. Based on some calculations and transformations similar to those made in [14], after limit passage when $l, k \to \infty$ one can get:

$$\frac{1}{2} \int_{0}^{R} \left[\left(\frac{\partial w(x,\tau)}{\partial t} \right)^{2} + a(x) \left(\frac{\partial w(x,\tau)}{\partial x} \right)^{2} \right] \varphi^{\beta} dx + \\ + \int_{\mathcal{Q}_{R,\tau}} a(x) \frac{\partial w}{\partial x} \frac{\partial w}{\partial t} \frac{\partial \phi^{\beta}}{\partial x} dx dt + \\ + \int_{\mathcal{Q}_{R,\tau}} \left(g \left(x, \frac{\partial u^{1}(x,t)}{\partial t} \right) - g \left(x, \frac{\partial u^{2}(x,t)}{\partial t} \right) \right) \times \\ \times \left(\frac{\partial u^{1}(x,t)}{\partial t} - \frac{\partial u^{2}(x,t)}{\partial t} \right) \varphi^{\beta} dx dt = \\ = \int_{\mathcal{Q}_{R,\tau}} (f - \overline{f}) \frac{\partial w}{\partial t} \varphi^{\beta} dx dt.$$
(8)

Let's estimate the integrals of equation (8) due to:

$$\begin{split} &\frac{1}{2}\int_{0}^{R}a(x)\left(\frac{\partial w(x,\tau)}{\partial x}\right)^{2}dx \geq \frac{a_{0}}{2}\int_{0}^{R}\left(\frac{\partial w(x,\tau)}{\partial x}\right)^{2}dx, \\ &\int_{Q_{R,\tau}}a(x)\frac{\partial w}{\partial x}\frac{\partial w}{\partial t}\frac{\partial \varphi^{\beta}}{\partial x}dxdt \leq M\int_{Q_{R,\tau}}\sum_{i,j=1}^{n}\frac{\partial w}{\partial x}\frac{\partial w}{\partial t}\frac{\varphi^{\frac{\beta}{2}}\varphi^{\frac{\beta}{p}}}{\varphi^{\frac{\beta}{2}+\frac{\beta}{p}}} \times \\ &\times\frac{\partial \varphi^{\beta}}{\partial x}R^{\alpha}dxdt \leq M\left(\int_{Q_{R,\tau}}\left(\frac{\partial w}{\partial x}\right)^{2}\varphi^{\beta}dxdt\right)^{\frac{1}{2}} \times \\ &\times\left(\int_{Q_{R,\tau}}\left|\frac{\partial w}{\partial t}\right|^{p}\varphi^{\beta}dxdt\right)^{\frac{1}{p}}\times\left(\int_{Q_{R,\tau}}\left|\frac{\partial \varphi^{\beta}}{\partial x}R^{\alpha}\right|^{p}dxdt\right)^{\frac{1}{p_{1}}} \leq \\ &\leq C_{1}\delta_{1}\int_{Q_{R,\tau}}\left(\frac{\partial w}{\partial x}\right)^{2}\varphi^{\beta}dxdt + \delta_{2}\int_{Q_{R,\tau}}\left|\frac{\partial w}{\partial t}\right|^{p}\varphi^{\beta}dxdt + \\ &+C_{2}\int_{Q_{R,\tau}}\frac{\beta \varphi^{(\beta-1)p_{1}}R^{\alpha p_{1}}}{\varphi^{\beta(p_{1}-1)}}dxdt \leq C_{1}\delta_{1}T\int_{0}^{R}\left(\frac{\partial w}{\partial x}\right)^{2}\varphi^{\beta}dx + \\ &+\delta_{2}\int_{Q_{R,\tau}}\left|\frac{\partial w}{\partial t}\right|^{p}\varphi^{\beta}dxdt + C_{3}\int_{Q_{R,\tau}}\varphi^{\beta-p_{1}}R^{\alpha p_{1}}dxdt \leq \end{split}$$

$$\leq C_1 \delta_1 T \int_0^R \left(\frac{\partial w}{\partial x} \right)^2 \varphi^\beta dx + \delta_2 \times \int_{\mathcal{Q}_{R,\tau}} \left| \frac{\partial w}{\partial t} \right|^p \varphi^\beta dx dt + C_4 R^{\beta - \frac{2p}{p-2}, \frac{2pw}{p-2}},$$

where: δ_1 , δ_2 - arbitrary sufficiently small positive constants, C_1 , C_2 , C_3 , C_4 - some positive constants that depend on the *p*, β . Note, that in the last evaluation we used Young inequality [8] and the properties of the φ function. Lets estimate the following integrals from equation (8):

$$\int_{Q_{R,\tau}} \left(g\left(x, \frac{\partial u^{1}(x,t)}{\partial t}\right) - g\left(x, \frac{\partial u^{2}(x,t)}{\partial t}\right) \right) \times \\ \times \left(\frac{\partial u^{1}(x,t)}{\partial t} - \frac{\partial u^{2}(x,t)}{\partial t} \right) \varphi^{\beta} dx dt \ge \\ \ge g_{0} \int_{Q_{R,\tau}} \left| \frac{\partial w}{\partial t} \right|^{p} \varphi^{\beta} dx dt, \\ \int_{Q_{R,\tau}} (f - \overline{f}) \frac{\partial w}{\partial t} \varphi^{\beta} dx dt \le C_{\delta} \times \\ \times \int_{Q_{R,\tau}} \left| f - \overline{f} \right|^{q} \varphi^{\beta} dx dt + \delta \int_{Q_{R,\tau}} \left| \frac{\partial w}{\partial t} \right|^{p} \varphi^{\beta} dx dt,$$

where: constant $C_{\delta} > 0$, and constant $\delta > 0$ can be made an arbitrarily small.

Taking into account the above estimates and using them, we obtain:

$$\begin{split} & (R-R_0)^{\beta} \left\{ \int_{0}^{R_0} \left(\frac{\partial w(x,\tau)}{\partial t} \right)^2 \varphi^{\beta} dx + \\ & C_5 \int_{0}^{R_0} \left(\frac{\partial w(x,\tau)}{\partial t} \right)^2 \varphi^{\beta} dx + C_6 \int_{\mathcal{Q}_{R_0,\tau}} \left| \frac{\partial w}{\partial t} \right|^{\beta} dx dt \right\} \leq \\ & \leq C_7 R^{\beta+1+(\alpha-1)\frac{2\rho}{p-2}} + C_8 R^{\beta} \int_{\mathcal{Q}_{R,\tau}} \left| f - \overline{f} \right|^q dx dt, \end{split}$$

 $C_5 - C_8$ - positive constants. From the last inequality easy to receive inequality (7).

Consider the next sequence of domains $Q^k = (0,k) \times (0,T)$, k = 1,2,... and respectively in each domain Q^k the problem:

$$\frac{\partial^2 u^k(x,t)}{\partial t^2} - \frac{\partial}{\partial x} \left(a(x) \frac{\partial u^k(x,t)}{\partial x} \right) + g\left(x, \frac{\partial u^k(x,t)}{\partial t} \right) = f^k(x,t),$$
(9)

$$u^{k}(x,0) = u_{0}^{k}(x), \qquad (10)$$

$$\frac{\partial u^k(x,0)}{\partial t} = u_1^k(x),\tag{11}$$

$$u^{k}(0,t) = u^{k}(k,t) = 0.$$
 (12)

Note that in equation (9) functions $f^{k}(x,t) = \begin{cases} f(x,t), x \le k, \\ 0, x > k. \end{cases}$. Also, instead of functions u_{0} functions u_{0}^{k} are discussed, where $u_{0}^{k}(x) = u_{0}(x) \cdot \xi_{k}(x), \quad \xi^{k} \in C^{1}(\mathbb{R}), \end{cases}$

$$\xi^{k}(x) == \begin{cases} 1, x \le k - 1, \\ 0, x > k, \end{cases}, \quad 0 \le \xi^{k}(x) \le 1.$$

It is clear that functions $u_0^k \in H_0^1(0,k)$ and $\lim_{k \to \infty} \left\| u_0^k - u_0 \right\|_{H_0^1}(0,k) = 0.$ Instead of the initial function u_1 consider the function u_1^k - narrowing of function u_1 on $(0,k), u_1^k \in L^2(0,k), \lim_{k \to \infty} \left\| u_1^k - u_1 \right\|_{L^2(0,k)} = 0.$

Under the generalized solution of problem (9) - (12) we mean function u^k , which satisfies (9) (10), (12) and the integral identity similar to the identity (5), which is treated in Q^k , where function v is chosen so that:

$$v \in L^{2}((0,T); H^{1}_{0}(0,k)) \cap L^{p}(Q^{k}),$$
$$\frac{\partial v}{\partial t} \in L^{2}(Q^{k}).$$

Note that under the conditions of the theorem there exists a unique generalized solution of the problem (9) - (12) in Q^k [14, p. 234].

Consider now the sequence of problems of the form (9) - (12) for $k = 1, k = 2, ..., u^k = 0$, when $(x,t) \in Q \setminus Q$. We will obtain a sequence of solutions of problem (1) - (4) in Q, which for convenience we denote again $\{u^k\}$. Lets show that sequence $\{u^k\}$ is fundamental in space:

$$C([0,T]; H^{1}_{0,loc}(0,+\infty),$$

and $\left\{\frac{\partial u^{k}}{\partial t}\right\}$ - fundamental in space:
$$C([0,T]; L^{2}_{loc}(0,+\infty)) \cap L^{p}_{loc}(\overline{Q}).$$

Consider the difference $u^l - u^m$, $l,m \in N$, m > l in domain $Q_{R,r}(1 > R > R_0)$ and we will use the inequality (7), taking into account that $f^l - f^m \equiv 0$ in $Q_{R,r}$. Similarly to (8) we obtain:

$$\int_{0}^{R_{0}} \frac{\partial}{\partial t} \left(u^{l}(x,\tau) - u^{m}(x,\tau) \right)^{2} dx + \\ + C_{1} \int_{0}^{R_{0}} \frac{\partial}{\partial x} \left(u^{l}(x,\tau) - u^{m}(x,\tau) \right)^{2} dx + \\ + C_{2} \int_{Q_{R_{0},\tau}} \left| \frac{\partial}{\partial t} \left(u^{l} - u^{m} \right) \right|^{p} dx dt \leq \\ \leq \frac{1}{\left(R - R_{0} \right)^{\beta}} C_{3} R^{\beta + 1 - \frac{2p}{p - 2}} + \\ + C_{4} \left\| u_{0}^{l} - u_{0}^{m} \right\|_{H_{0}^{1}(0,R_{0})} + \\ + C_{5} \left\| u_{1}^{l} - u_{1}^{m} \right\|_{L^{2}(0,R_{0})}.$$
(13)

From inequality (13) by proper a choice of sufficiently large R > 0:

$$\int_{0}^{R_{0}} \frac{\partial}{\partial t} \left(u^{l}(x,\tau) - u^{m}(x,\tau) \right)^{2} dx + \\ + C_{1} \int_{0}^{R_{0}} \frac{\partial}{\partial x} \left(u^{l}(x,\tau) - u^{m}(x,\tau) \right)^{2} dx + \\ + C_{2} \int_{\mathcal{Q}_{R_{0},\tau}} \left| \frac{\partial}{\partial t} \left(u^{l} - u^{m} \right) \right|^{p} dx dt \leq \varepsilon,$$

for any arbitrarily small $\varepsilon > 0$. Thus, $\{u^k\}$ is fundamental sequence in space $C([0,T]; H^1_{0,loc}(\overline{\Omega}))$, namely:

 $u^k \to u$ strongly in $C([0,T]; H^1_{0,loc}(0,+\infty))$, and sequence $\left\{\frac{\partial u^k}{\partial t}\right\}$ is fundamental in space

$$C([0,T]; L^{2}_{loc}(0,+\infty)) \cap L^{p}_{loc}(Q), \text{ namely:}$$

$$\frac{\partial u^{k}}{\partial t} \rightarrow \frac{\partial u}{\partial t} \text{ strongly in space: } C([0,T]; L^{2}_{loc}(0,+\infty)) \cap C^{p}_{loc}(\overline{Q}).$$

It is obvious that for function u, conditions (2) - (4) are satisfied. Thus, u is a generalized solution of problem (1) - (4) in the sense of the integral identity (5), for which inclusion performed (6) performed.

Uniqueness of the obtained solution follows from inequality (13) with $R \rightarrow +\infty$, if we consider two arbitrary solutions u^1 and u^2 of problem (1) - (4) and considering that:

$$\frac{u^{1}(x,0) = u^{2}(x,0),}{\frac{\partial u^{1}(x,0)}{\partial t} = \frac{\partial u^{2}(x,0)}{\frac{\partial t}{\partial t}}.$$

Note that for problem (1) - (4) it is easy to obtain sufficient conditions for the existence and uniqueness of periodic for the spatial variable generalized solution to problem (1) - (4).

Let conditions (I), (II), (III), (IV) are satisfied, $\alpha = 0$ and exist such number $\zeta > 0$, that:

- a) $a(x + \zeta) = a(x)$ for all $x \in (0, l)$;
- b) $f(x + \zeta, t) = f(x, t)$ for nearly all $(x, t) \in Q$;
- c) $u_0(x + \zeta) = u_0(x), u_1(x + \zeta) = u_1(x)$ for nearly all $x \in (0, +\infty)$.

Then problem (1) - (4) has a unique generalized solution u, which is periodic function by variable x with period ζ .

Really, since there is unique generalized solution of the problem (1) - (4) and function $u(x + \zeta,t)$, $(x,t) \in Q$ also is a generalized solution of problem (1) - (4) (it is easily verified), then from the uniqueness of the generalized solution immediately follows that $u(x + \zeta,t) = u(x,t)$ for nearly all $(x,t) \in Q$.

CONCLUSIONS

- Firstly obtained correctness conditions for the solution in mathematical model for fluctuations of semiunbounded rope under the influence of nonlinear resistance force - sufficient conditions for the existence and uniqueness of solution in the class of locally integrable functions.
- 2. The above technique allows substantiate the correctness of the model also in the more complex case the vibrations under the action of combined effects of nonlinear elastic foundation and resistance forces. This mathematical model is reduced to a qualitative analysis of the mixed problem in a bounded (in the case of a finite cable) or unbounded (as discussed in this article) domain for the equation:

$$\frac{\partial^2 u}{\partial t^2} - \frac{\partial}{\partial x} \left(a(x) \frac{\partial u}{\partial x} \right) + g\left(x, u, \frac{\partial u}{\partial t} \right) = f(x, t).$$

3. These qualitative results justify, particularly the possibility of applying for such problem Galerkin numerical method and provide an opportunity to apply various approximate methods in further investigations of the dynamic characteristics of the considered oscillation mathematical models solutions.

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Locus nascendi factors for the economic goods allocation

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A b s t r a c t. The paper presents the economic goods allocation depending on their production factors. The feasibility study is made for the existence of four groups and several subgroups of economic goods, dominated by one "Siamese" pair. The classification of economic goods depending on their place of production factors is made, that will help to improve the quality and efficiency of decision making on the choice of the optimal production placement.

Key words: economic goods' classification, production factors, possible production placement, investments.

INTRODUCTION

It is known that economic benefit is something that has the property of value, that is capable to satisfy certain human needs directly or indirectly. An example of benefit can be, for instance, car, land, bread, scientific work, performance, software, electrical energy. However, the economic benefit is not only something that can directly satisfy human needs, but also something that can be used to satisfy an indirect need. The founder of the Austrian school of political economy - Carl Menger proposed a classification of goods depending on the possibility of their use for the direct satisfaction of human needs: he divided all goods for the benefit of the first order (this is the benefit that can be used directly for human purposes) and goods of higher order (second, third and so on, which can not be directly used by man) [1]. According to such a division, bread is the benefit of first order, grain from which it its baked - of the second order, grain from which flour is made - of the third order, etc.

Obviously, all goods are derived from the nature, but they need some exposure to activity to become ready for consumption. Even to eat strawberries, you must first gather, to eat nuts they must first be split. However, a person needs a much wider range of goods than nature allows. Because people have learned they need to create goods by influencing the goods existing in nature. The process of creating the right goods is called production. Thus, goods are divided into the gift, (non-economic) that are created by nature (air, water, oil), and economic, resulting from human activities (car, bread, gasoline). In economic theory many approaches are known to the goods classification, but goods have never been classified according to the factors of their locus nascendi (LN) (place of origin, place of birth) [1, 2, 3, 4, 5, 9].

THE CONCEPT

First of all we formulate some definitions: place of creation of goods (LN), place where non-economic benefit or economic benefit is formed (production), the factors of goods creation in a particular place, the reasons which should be considered in order to predict (forecast) the future LN by answering the question "where?" or explaining the already existing (old) LN by answering the question "why here?".

The formation of LN factors of goods creation should be performed by considering the properties of places that are favorable for the goods creation. In order to detect a favorable place we should depend on the properties on the "goods" side, that include the following features:

- the production technology (or creation) of goods,
- $-\,$ the resources needed for technologically created goods,
- the pollutants that are formed during the process of benefit creation.

The "goods" side (which are created or are to be created) and side "place" (which is or should be a goods' LN) are characterized by a certain set of properties, some of which are factors of LN of goods. Factors that determine LN of goods can be divided into internal (which include the features of those "goods" only) and external (the features corresponding to "place"). Thus we have, on the one hand, the properties of the "goods" part, some of which should be considered as LN factors of goods. On the other hand, the properties of each side of "goods" correspond to the feature of "place", which should also be considered as an LN factor. LN benefit is characterized by a certain set of properties, some of which are LN factors of goods [9].

First, it is appropriate to comply the general division of goods from their LN factors by separating blessings on those LN which is due to the dominant "Siamese" pair of factors (block A goods general division) and those, LN which is due to several "Siamese" pairs of factors (goods block in general division). In a subsequent study of gift, (non-economic goods) remain unnoticed because the factors driving LN is the subject of geological survey and other sciences of nature and not amenable to optimization in terms of human interests. Therefore, we consider further investigation of the LN factors on economic goods. First, focus on the study of the economic goods of block A, which are divided into 4 groups, and a number of subgroups within these groups.

• Group 1 of economic factors of A block:

Types of goods for which LN is possible. The place with the presence of a suitable resource. The concept of source resource includes not only natural resources (mineral deposits, forests, farmland, clean environment, etc.), but also the resources of anthropogenic origin (e.g. sugar, cement, relatively cheap emission reductions in the region, while ensuring environmental sustainability or low requirements of state to environmental impact). It is clear that extreme volumetric term "resource" potential causes further division types of economic goods group 1 (which includes three subgroups) on LN factors not only within the group but also subgroups.

• Subgroup 1 from group 1 of economic factors, block A: Types of goods for the production of property "the need for non-mobile resource" is dominant. This subgroup includes kinds of goods for the production of resource extracted from its source (the development of minerals, timber industry, fishing, relatively cheap emission reductions in the region, while ensuring environmental sustainability, etc.) or are immobile resources (such as transportation use of lake energy, use of the river, a clean environment, low requirements to the state of the business impact on the environment). For the types of goods subgroup 1 of group 1 pair of Siamese factors LN is "the need for non-mobile resource" (property side of "good") -"the existence of non-mobile resource's source" (property of the side's place ").

• Subgroup 2 from group 1 of economic factors, block A: The types of goods for which the "resource-capacity" feature is high (high cost per unit of the relevant resource) is dominant. Level of resource-capacity characterized by resource-capacity index, calculated as the ratio of raw material to goods supply cost of this (especially when you need to pay duty on export goods), large size (like construction house-building factory), the possibility of loss of quality (bread, flour, some confectionery, dairy products, thermal energy etc.), security issues (such as sulfuric acid, explosives). For the types of goods subgroup 1 Group 2 pair of Siamese factors LN is "good's low mobility" (the side feature of "goods") - "the existence of consumers '(the feature of the side - "place").

• Subgroup 2 from group 2 of economic factors, block A:

The goods types for which the property "weight (volume) benefit exceeds the weight (volume) of the mining resource" is dominant. It happens, when for the benefit's production to the basic resource, another freely available resourses are added (water and air). Therefore, insulating building materials, which are produced by hot air of raw materials treatment (usually clay), have a strong consumer orientation. It is similar with the beverage industry, brewing, production of refreshment drinks from concentrates, etc., a tangible component of which is water. The world's largest factory concentrate "Coca-Cola" is located on the island of Puerto Rico. This product is sent to 1,145 companies worldwide which add water to concentrate and pour the legendary drink in various capacities for retail sale. It is drawing attention, however, to the possibility of exceptions in subgroup 2 group 2. For instance, Heineken beer was never produced in the USA, where it has high demand from consumer, since its European origin feature is crucial. For the types of goods sub 2 Group, 2 pair of Siamese factors LN is "weight (volume) benefit exceeds the weight (volume) of the main resource" (the feature of "good" side) - "the existence of consumers" (the property of the side "place").

• Subgroup 3 from group 2 of economic factors, block A:

The types of goods for which the "negligible spatial differentiation cost of goods' production" feature is dominant. Consumer's targeting this subgroup intention is to save on costs associated with the movement (good to customers or consumers to benefit) in the impossibility to save on production costs. For the types of goods subgroup 3 Group 2 pair of Siamese factors LN is "negligible spatial differentiation expenses birth" (property side of "good") - "the existence of consumers '(the side's feature' place").

• Subgroup 4 from group 2 of economic factors, block A:

The types of goods for which the "cultural (mental) relation need of employees with consumers benefit" feature is dominant. Therefore, companies that do not require proximity to customers for technical reasons, are oriented on the need of cultural affinity. Thus, companies that deal in European Union retail via phone or Internet, located in Hungary and Bulgaria, where the business costs will be larger than, for example, in India, but at the same time don't have significant difference in mentality between employees and customers. For the types of goods from sub 4 group of 2 Siamese pair factors LN is a " the need of mental affinity of employees with benefit consumers" (property side of "good") - "the existence of consumers" (property side "place"). • Subgroup 5 from group 2 of economic factors, block A:

The types of goods for which the property "the need of direct contact consumers with employees" is dominant. Direct contact with consumers creates opportunities for rapid response needed to improve the existing goods of producing new wealth, often customized to individual needs. It also facilitates the organization of the service. For the types of goods subgroup 5 Group 2 pair of Siamese factors LN "the need for direct contact in between consumers and workers" (the "good" feature) - "the existence of consumers '(the feature for the side "place").

• Subgroup 6 from group 2 of economic factors, block A:

The goods types for which the property "immobility good" is dominant (eg, good, producing hotels, shops, restaurants, stadiums, etc.). For these types of goods is important to clearly identify consumer goods and estimate the amount of their demand. If the demand for the good in the jurisdiction is not less than the threshold (the level of demand for the good that determines the feasibility of producing this

For example, the resource-capacity index for: oil - 2,5:1; sugar - 7-1; cheese - 9:1; butter - 24:1. Especially demanding are dried mushrooms, fruits and vegetables. For the types of goods from sub 2 Group 1 pair of Siamese factors LN is high "resource-capacity" (the feature of "goods" side) - "sources of resource availability" (the feature of the side "place"). Resource-intensive production orientation kinds of goods conditional desire to save on transport costs.

• Subgroup 3 from group 1 of economic factors, block A: The types of goods for which the feature of "use of low mobile resource" is dominant. The production of canned food, wine, juices, etc. focus on sourcing as moving under vegetables, fruit, fish, etc. accompanied by a significant loss of quality or costly to prevent this in the way. For the types of goods subgroup 3 Group 1 pair of Siamese factors LN is "use of low mobile resource" (property side of "good") - "the existence of sources low mobile resource" (property of the parties "place ".

Group 2 of economic factors of A block:

The types of goods for which LN factor is the the market (consumers) proximity. Targeting consumers can be seen across the country, region or city. Group 2 kinds of goods includes six subgroups.

• Subgroup 1 from group 2 of economic factors, block A: Types of goods for which the property "good's low mobility" is dominant. Low mobile benefit is difficult to transport a long distance through the cost of this (especially when you need to pay duty on export goods), large size (like construction house-building factory), the possibility of loss of quality (bread, flour, some confectionery, dairy products, thermal energy etc.), security issues (such as sulfuric acid, explosives). For the types of goods subgroup 1 Group 2 pair of Siamese factors LN is "good's low mobility" (the side feature of "goods") - "the existence of consumers '(the feature of the side - "place").

• Subgroup 2 from group 2 of economic factors, block A:

The goods types for which the property "weight (volume) benefit exceeds the weight (volume) of the maining resource" is dominant. It happen, when for the benefit's production to the basic resource, another freely available recourses are added (water and air). Therefore insulating building materials, which are produced by hot air of raw materials treatment (usually clay), have a strong consumer orientation. It is similar with the beverage industry, brewing, production of cooling drinks from concentrates, etc., tangible component of which is water. The world's largest factory concentrate "Coca-Cola" located on the island of Puerto Rico. This product is sent to 1,145 companies worldwide which add water to concentrate and pour the legendary drink in various capacities for retail sale. It is drawing attention, however, to the possibility of exceptions in subgroup 2 group 2. For instance, Heineken beer was never produced in the USA, where it has high demand from consumer, since it's European origin feature is crucial. For the types of goods sub 2 Group, 2 pair of Siamese factors LN is "weight (volume) benefit exceeds the weight (volume) of the main resource" (the feature of "good" side) - "the existence of consumers" (the property of the side "place").

• Subgroup 3 from group 2 of economic factors, block A:

The types of goods for which the "negligible spatial differentiation cost of goods' production" feature is dominant. Consumer targeting this subgroup intention is to save on costs associated with the movement (good to customers or consumers to benefit) in the impossibility to save on production costs. For the types of goods subgroup 3 Group 2 pair of Siamese factors LN is "negligible spatial differentiation expenses birth" (property side of "good") - "the existence of consumers '(the side's feature' place").

• Subgroup 4 from group 2 of economic factors, block A:

The types of goods for which the "cultural (mental) relation need of employees with consumers benefit" feature is dominant. Therefore, companies that do not require proximity to customers for technical reasons, are oriented on the need of cultural affinity. Thus, companies that deal in European Union retail via phone or Internet, located in Hungary and Bulgaria, where the business costs will be larger than, for example, in India, but at the same time don't have significant difference in mentality between employees and customers. For the types of goods from sub 4 group of 2 Siamese pair factors LN is a " the need of mental affinity of employees with benefit consumers" (property side of "good") - "the existence of consumers" (property side "place").

• Subgroup 5 from group 2 of economic factors, block A: The types of goods for which the property "the need of direct contact consumers with employees" is dominant. Direct contact with consumers creates opportunities for rapid response needed to improve the existing goods of producing new wealth, often customized to individual needs. It also facilitates the organization of the service. For the types of goods subgroup 5 Group 2 pair of Siamese factors LN "the need for direct contact in between consumers and workers" (the "good" feature) - "the existence of consumers '(the feature for the side"place").

• Subgroup 6 from group 2 of economic factors, block A:

The goods types for which the property "immobility good" is dominant (eg, good, producing hotels, shops, restaurants, stadiums, etc.). For these types of goods is important to clearly identify consumer goods and estimate the amount of their demand. If the demand for the good in the jurisdiction is not less than the threshold (the level of demand for the good that determines the feasibility of producing this good), then the appropriate place can be considered as a possible place of production. For example, the stores are profitable when the space catalog (the maximum distance that a buyer is willing to overcome in order to purchase the goods), presented in them is greater than the threshold number of consumers (at least potential customers store needed to sell all the goods). Thus, 66% of food customers spend on their way to store up to 10 minutes, while 25% spend 11-20 minutes on the road, and 7% -21-30 minutes. Similar trends have been observed for other groups.

For the types of goods sub 6 Group 2 pair of Siamese factors LN is "immobility good" (the side feature of "good") - "the existence of consumers" (the side's feature – "place").

• Group 3, economic goods, block A:

The goods types for which the feature of "minimal production costs" is dominant. Indicative in this respect is the area of software (the worldwide center of which is India), providing a variety of accounting and consulting services (Poland conducts accounting firms to other European Union countries, including Germany, UK and France), where goods are made with minimal production costs and with help of Internet can be very quickly delivered to customers. Canadian company "Guest-Tek", which specializes in Internet - services for hotels in Poland opened its European Service Centre, with 200 people stuff. The center provides remote technical support for hotels customers, which serve the Canadian company. The companies, that are belonging to them include the network "Accor", "Hilton", "Hyatt", "Intercontinental" and "Mariott" in the United States, Canada and Western Europe. In the U.S. favorable soil and climate conditions zones are used for growing potatoes and are mainly in the northern states on light soils under irrigation, located at a considerable distance 2,5-4 thousand km. from the main centers of consumption, despite the fact that this crop can be grown in the U.S. in almost all states. This situation is the result of good transportability for potatoes. For the group 3 of producing goods Siamese factors LN is "high transportability good" (property of the parties "production of goods") - "low cost of production of goods" (property of the parties "place").

pq	LN dominant factor			
The group of goo production	The sides of "goods production"	The side «place»	Possible LN place, that has:	
1	1.1. The use of non mobile recourse	Presence of low mobile resource source	The sources of certain resources	
	1.2.High recource capacity	Presence of resource source		
	1.3. The use of non mobile recourse	Presence of low mobile resource		
2	2.1. Production of low mobile goods	Presence of customers		
	2.2.Weight (volume) of produced benefits exceeding the weight (volume) of the basic resource	Presence of customers		
	2.3.Low spatial differentiation of goods production costs	Presence of customers		
	2.4. The need for customers and employees mental affinity	Presence of customers	Customers	
	2.5.The need for direct contact employees and customers	Presence of customers		
	2.6.Low mobility of produced good	Presence of customers		
3	High transportability of produced goods	Low production costs for corresponding goods	The possibility of lowering production costs	
4	anger for the population The distance from settlements		The distance from settlements	

Table 1. The classification of economic benefits of LN that is determined by dominant "Siamese pair" factors

• Group 4, economic goods, block, A:

The goods types for which "the safe distance from major population centers" is dominant. Many types of production goods are dangerous to the environment and population: It is necessary to recall the nuclear accident in Chernobyl, located near Kyiv. The accident at Chernobyl was the worst in nuclear history. It resulted from an erroneous placement of reactor - near densely populated area, close to major cities, reservoirs and rivers that provide these cities. For species producing goods group 6 pair of Siamese factors LN is a "danger to the public" (property of the parties 'production of goods ") - "remoteness from human settlements" (the feature "place").

In the Table. 1 is given summary for the classification of economic goods from LN factors, dominated by only one pair of "Siamese" factors. In many cases, the factors of LN goods are several "Siamese pairs". Indicative in this respect is the requirement of "McDonald's in Ukraine" (fast food restaurants) to possible LN locations: "McDonald's will consider proposals for the purchase or long-term land lease for the construction of its facilities in Kiev and other regions of Ukraine. The company is also interested in acquiring or renting commercial premises for containing the catering requirements for land: location - downtown streets and highways crossing heavy traffic and pedestrian flows, congestion places trade and entertainment. Area: 1500-3500 m². requirements areas: location requirements - front sid e rooms that overlook the downtown streets and highways crossing heavy traffic and pedestrian traffic, subway stations and transport interchanges. Considering also placing in shopping centers - preferred corner room. Area: 350 - 500 m². The minimum ceiling height - 3,5 m, energy supply: 1) power - 150 kW (Power consumption), II category of energy, 2) water and sewerage - 15 cubic meters. per day, 3) heat - 110-115 Gcal or possible arrangement of their own mini-boiler on natural gas.

Another example is the automobile factory in Montgomery (Alabama), which was the first manufacturing investment of "Hyundai Motor" in the United States. The value of investing \$ 1 billion., Capacity - 300 thousand cars annually. The need for labor - 2000 people, including 1600 - production workers and 400 - managers, maintenance and administration of the factory. Concern named key factors for choosing Montgomery for plant placement: skilled labor availability, relatively low labor costs, good infrastructure and convenient road connection to the rest of the country, a very well-developed network of cooperators, generous package of financial incentives and personal involvement of Alabama and Montgomery authorities. Important were also very attractive area parameters (location and geological conditions), and the proximity of modern sea Mobil port. Since Mobil helded components delivery from Korea, and exported finished cars to the markets of South America. Making a decision concerning factories placing, the "Hyundai" management took into account even climatic factors. It is worth noting that one of the reasons for rejection of the Mississipi State Authorities proposal was the fact that the proposed

placement was too close to the "Nissan" plant, which raised fears for the possibility of competition with the Japanese concern for employees. It should also be noted that placing the company in the United States enabled the company to limit the risks associated with currency fluctuations (this factor has limited space analysis of state boundaries USA). And besides, some people noticed that "Hyundai" traditionally has problems with unions, and Alabama State, as, after all, in most southern U.S. states, can be characterized by weak unions not least because of the relevant legislation.

In the Table. 2 the classification of economic goods, which LN is due to several "Siamese pairs" factors. In this table the possibility of providing information about resources is enhanced because both factors of LN goods may be several different resources. The groups of production goods in the block B are formed by various combinations of already established "Siamese" pairs factors. For example, for the goods of B block, group 1 LN factors will be a combination of factors, "the presence of a suitable resource" and "the existence of consumers" (1+2). The existence of a suitable resource automatically generates the possibility of large subgroups, as shown in Figure 1.

Table 2. Classification of economic benefits, whose LNare determined by several "Siamese pair" factors

The "Siamese pair" factors		The types of goods production				
		Б	Б2		Б _N	
	1.1	Resource 1.1.1	Х	Х		
		Resource 1.1.2		Х		
		Resource 1.1.Y				Х
	10	Resource 1.2.1				
		Resource 1.2.2		Х		
1	1.2					
		Resource 1.2.Y				
	1.3	Resource 1.3.1				
		Resource 1.3.2				
		Resource 1.3.Y				
2	2.1			Х		
	2.2					
	2.3		Х			
	2.4					
	2.5					
	2.6					
3						
4			Х			



Fig. 1. The economic benefits classification according to their LN factors

It is similar for all goods in B group, where among the LN factors appears «the availability of a suitable resource» factor and any one factor: the good block in group 2 (1+3) and good block in group 2 (1+4). After all, there are many subgroups and other goods within a block, where among the factors LN appears factor «presence of a suitable resource» and a few other factors: good block in group 4 (1+2+3), good block in group 5 (1+2+4) and a good block group 6 (1+3 +4). Good block in the other groups - 7 (2+3), 8 (2+4), 9 (3+4) and 10 (2+3+4) - characterized by the absence of subgroups, as among the factors they LN no factors that generate their necessity.

CONCLUSIONS

The study gives classification of economic goods from their LN factors, that aims at improving the quality and speed of decision making on the location' optimal choice for good's manufacturing. Further studies in this area are promising in the field of identifying more LN factors, their possible economic benefits and filling up developed classification schemes with more specific information.

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A conceptual scheme for modelling forestry and LUC CO, emissions in Ukraine

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A b s t r a c t. A number of global land-use change and forest management models for studying CO_2 emissions in land-use change and forestry, in particular: G4M, GLOBIOM, Land-SHIFT, GTM and GCOMAP are considered. The main issues and features of forestry in Ukraine (e.g. illegal forest harvesting, lack of reliable and consistent data on forestry, difference between concepts of Ukrainian and international legislation in forestry) are analyzed. A conceptual scheme for modelling forestry and land-use CO_2 emissions in Ukraine is developed.

Key words: LULUCF, CO_2 emissions, Ukraine, information technology, modeling.

INTRODUCTION

Greenhouse gas (GHG) emissions from land use, land use change and forestry (LULUCF) approximately account for 25% of total GHG emissions [3,4,21,29]. In 1993 – 2003 the terrestrial carbon sink in forests was about 3300 MtCO₂/yr [5]. Carbon stocks in tropical forest are about 271,7 tons per ha, temperate forests - 167,96 tons per ha and boreal forests in average 449,54 tons per ha [26]. During the last centuries total forest area is decreasing mainly because of forest land conversion to another land use. Since 1850 about 600 million ha of forests and woodlands all over the world have been converted into croplands [24,31]. The planet is losing about 13 million ha of forest lands every year [15]. In some countries changing forest to another type of land use is one of the largest sources of CO₂ emissions. Loss of forest area means not only increased CO, emission but also negative impact on biodiversity, water regulation, soil formation and climate mitigation [13,35]. Considering the above facts it is not surprising that LULUCF attracts high attention of international community.

The 15th Conference of Parties (COP) of United Nations Framework Convention on Climate Change (UN-FCCC) in Copenhagen resulted in a set of decisions named "Copenhagen Accord". "Copenhagen Accord" acknowledges: "the importance of reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries" [6]. During the 17th COP in Durban in 2011 the Kyoto Protocol was prolonged. The second commitment period begins 1 January 2013 and ends 31 December 2017 or 31 December 2020 [7]. The most important issues concerning LULUCF are:

- Subsidiary Body for Scientific and Technological Advice (SBSTA) must develop working program to explore more comprehensive accounting of anthropogenic emissions by sources and removals by sinks from LULUCF [7],
- SBSTA also need to consider, develop and recommend modalities and procedures for possible additional land use, land-use change and forestry activities under the clean development mechanism [7].

Countries will have much more possibilities to improve forest management and reduce deforestation if additional LULUCF activities are developed.

Ukraine is a Party of the UNFCCC, the Kyoto Protocol and the second commitment period of the Kyoto Protocol [7]. We expect that Ukraine will also be an active member at future climate negotiations. Because of the growing attention to role of LULUCF in reducing CO_2 emissions, Ukraine needs to explore the potential of this sector.

LAND-USE CHANGE AND FORESTRY IN UKRAINE

Ukraine is a country with low forest cover. According to the Agency of State Forestry Resources of Ukraine (ASFRU) about 15,7 % of the country territory is covered by forestlands. Forest cover differs in the natural zones of Ukraine and is the largest in Polissja and Carpathian Mountains - more than 40 % [23]. In the past a large part of forests were lost but in 50-70s of 20th century a substantial amount of new forests were created [19]. Therefore about 50 % of Ukrainian forests are artificially planted [8] and consequently 45 % of forest stands are middle age [11]. Prevailing wood species are pine, oak, beech and fir [23]. Most of the forestlands are managed by ASFRU (68%), the other parts – by Ministries and other institutions (25 %) and 7 % are reserved and unmanaged forestlands [11].

Managed forests in Ukraine absorb approximately 22,6 - 23,3 MtCO₂/yr annually [33]. National CO₂ inventory in LULUCF sector reports net absorption in 1990-2010 [20]. Changes in pools of mineral soils of "Grasslands" and "Tillage" categories determine the CO₂ emissions in LULUCF sector [8]. The loss of carbon because of wood harvesting and forest fires on managed forest areas has changed between 4,2 and 5,3 Mt CO₂/ yr [33]. Net absorption of carbon in LULUCF sector has been reduced by 40 % since 1990 [8].

Biomass is the largest source of carbon sequestration in the category "Forests" [22]:

- almost 70 % of carbon live biomass,
- approximately 30 % dead biomass,
- less than 1% litter.

The state target program "Forests of Ukraine" for 2010 - 2015 [30] reports a potential of increasing net CO₂ absorption by forestlands. In the program two scenarios were developed – the most probable and optimistic. According to the most probable scenario the amount of CO₂ absorption in forestry will reach 53,1 Mt CO₂ in 2015, according to the optimistic scenario the absorption will be 42,1 Mt CO₂. Such big difference between the scenarios exists because the optimistic scenario considers increasing wood harvest.

According to recent studies Ukraine has a potential to reduce CO₂ emissions in LULUCF sector by increasing carbon absorption by forest biomass. There are albeit some problems which prevent using possible opportunities for emission reduction. For example, the state program "Forests of Ukraine" [30] contains predictions of carbon absorption but a concrete action plan has not been developed yet. The state program "Forests of Ukraine" pays more attention to afforestation and reforestation as methods for reducing emissions and less attention to improving forest management and land-use change.

There are some difficulties in estimation of afforestation and reforestation amount. In Ukraine a concept of optimal share of forestlands is used. Actual share of forestlands in the country is 15,7 % and optimal -20 % [11]. Some Ukrainian researchers do not agree with such value of the optimal share of forestland. They explain that the information and data used for estimation of the optimal forestland share is outdated and wrong [9]. Nevertheless, all the governmental documents on forestry are based on that optimal share of forestland, which was developed in 1966 [32]. Because of that all the predictions of forest cover and emission in LULUCF sector made in the state program may be inadequate.

Researchers face serious problems on their way to assess the development of forestry and level of emissions in LULUCF sector of Ukraine:

- lack of reliable and consistent data about forests and amount of illegal forest harvesting [25],
- basic concepts in forestry used in Ukrainian legislation differ a lot from the concepts used on international level [9],
- Popkov and Savushchuk [32] emphasize that the existing government's plans on forestry development are based on wrong and outdated facts.

We expect that a number of projects which have been developed in recent years will improve availability of data necessary for the estimation of CO_2 emissions in the LULUCF sector (e.g.: a system of electronic inventory of wood, land inventory of Ukraine which should become available in electronic form at the beginning of 2013 [1], a composite land cover map being developed in the frameworks of the GESAPU project).

USAGE OF INFORMATIONAL TECHNOLOGIES FOR STUDYING ECOLOGICAL PROBLEMS

In environmental studies information technologies are used for gathering, storing and processing data, monitoring, analyzing and modelling of processes and effects etc. Application of earth surface modelling has begun in the middle of 19th century but the first computer-oriented mathematical models were developed in 1970s. Also 1970s is the period of active growth of terrestrial ecosystem modelling and in 1972 first semi-mechanistic computer model of forest growth was developed [34].

A lot of computer models are developed for LU-LUCF sector. The models operate on different scales and are focused on particular sides of the sector. A review of existing experience in LULUCF modelling is important for developing a conceptual scheme of a new LULUCF model on the country scale. We selected the following models for a more detailed analysis: Global Forest Model (G4M), Global Biomass Optimization Model (GLOBIOM), LandSHIFT, Global Timber Model (GTM) and Generalized Comprehensive Mitigation Assessment Process (GCOMAP).

Global Forest Model (G4M) is a geographically explicit ($0,5 \times 0,5$ degrees regular grid) economic model that simulates making land-use change decisions and provides projections of afforestation and deforestation rates, forest management options and respective CO₂ emissions and sinks [2]. The model consists of five modules: Virtual forest, Forest initialization, Forest management decisions, Land-use change decisions and Forest dynamics. LUC decisions are made by comparing net present value of forestry with net present value of agriculture for each grid cell [16]. Forest management decisions are made to match wood production exogenously specified for countries or regions [2]. The model uses a large amount of data on

different scales: global, regional, country and grid [16]. G4M is connected with GLOBIOM model which, in particular, estimates dynamics of wood production, wood and agriculture land prices for G4M [2]. Results of G4M were used in a number of assessments such as Eliasch Review, the Economic Assessment of Post-2012 Global Climate Policies, Roadmap for Moving to Lowcarbon Economy in 2050 and applications www.forestcarbonindex.com and OSIRIS [16].

Global Biomass Optimization Model (GLOBIOM) is a dynamic bottom-up partial equilibrium model of total land-use developed at the International Institute of Applied System Analysis. The model simulates competition for land between different uses driven by price and productivity changes. In GLOBIOM the world is divided into 50 economic regions and the model is focused on agriculture, forestry and biofuel production in each region. Structure of the model consists of three parts: different land uses (managed and unmanaged forest, short rotation tree plantation, cropland, grassland, other natural vegetation), processes (wood processing, bioenergy processing, livestock feeding) and commodities produced (forest and energy products, crops, livestock). GLOBIOM estimates greenhouse gas emissions and sinks from agriculture and forestry. GLOBIOM uses a number of input data from other models, in particular: EPIC (agriculture model that provides biophysical parameters and constraints), G4M (biophysical constraints of the forestry sector), CAPRI (external projections, technical restrictions and information included in historical time series to develop projections of the agricultural sector), PRIME/POLES (external projection of bioenergy demand). GLOBIOM was used to assess the first and second generation of biofuels expansion [17].

LandSHIFT is an integrated, medium-term scenario analysis (20-50 years) model which uses "land-use systems" approach. The aim of the model is to simulate land-use and land-cover changes on continental and global scales and describe interlink between anthropogenic and environmental system components as drivers of land-use change. The structure of LandSHIFT consists of two components: LUC-module, which simulates land-use change and Productivity module, which calculates the crop yields and net primary production of grasslands. The model operates on a macro-level (driving variables describing socio-economic and agricultural development of a country) and micro-level (grid variables describing local landscape characteristics and zoning regulations). According to UN Food and Agriculture Organization the macro-level includes 179 countries; each country is divided at the micro-level into a grid, the cell size is approximately 9×9 km [27]. In comparison with the above-mentioned models, LandSHIFT simulates land use change without forest management and LULUCF CO₂ emissions.

Generalized Comprehensive Mitigation Assessment Process (GCOMAP) is a dynamic partial equilibrium model. The aim of the model is to simulate the response of the forestry sector to changes in future carbon prices. The model covers ten world regions and is divided into three modules: the first module computes annual changes in carbon stock over the model time horizon, the second module computes the financial viability of the forestry option and the third module estimates the changes in land use that result from a carbon price scenario. GCOMAP concentrates on simulating climate mitigation options for every region separately. The model considers long and short rotation forests, biofuels and avoided deforestation [12].

Global Timber Model (GTM) is an economic model for examining global forestry land-use, management and trade responses to policies [28]. In response to the policy, the model simulates afforestation, forest management, and avoided deforestation behavior and also estimates harvests in industrial forests and inaccessible forests, timberland management intensity, and plantation establishment, all important components of both future timber supply and carbon sinks [28]. The model divides the world into 13 regions [12]. GTM differs from the other models by the fact that it simulates global timber market in detail including forest management. At the same time it considers land-use change only in context of avoided deforestation.

MODELLING LULUCF CO₂ EMISSIONS: MAIN DRIVERS

Modelling is an appropriate method for assessing a potential of reducing CO_2 emissions in LULUCF sector in Ukraine. The main goal of modelling CO_2 emissions in LULUCF sector is studying current and future dynamics of the emissions on a selected territory under different scenarios of socio-economic development.

A conceptual scheme for modelling forestry and LUC CO₂ emissions is shown in Fig. 1.



Fig. 1. Conceptual scheme for modelling forestry and LUC CO, emissions

A model for assessment of CO_2 emissions in LUC and forestry requires a large amount of input data. The obtainment of all the required reliable data may be problematic. Therefore, the model scheme may be modified in the future, due to absence of some data.

Taking into account the above-considered experience of such models, we plan to use geographically explicit approach applying a regular grid. The grid cell size depends on available data and borders of administrative units. Also, an important issue is to find such a size of grid cell which will be optimal for making an adequate decision about the type of land-use and forest management in the cells.

Each grid cell will contain information on land cover and main land uses (e.g. area of forest, agriculture and infrastructure objects) as well as more detailed information about the objects. For forests it is forest type, forest age structure, tree species composition, forest biomass, soil type, suitability for agriculture, carbon stock in coarse woody debris and soil organic matter etc. For agriculture land it is soil type, productivity, carbon stock in soil organic matter and litter etc. For infrastructure it is the type of the object. The cells also will contain information on the owners of forests, agriculture lands or infrastructure objects: state, municipal, private or unknown since this might influence decisions on land use change and forest management.

Environment is tightly connected with economy, politics and society of the country. Every decision made to achieve goals of environmental policy affects the economy of the country. Vice versa, political and economic decisions have an impact on the environment. It is important to find such policy, under which economic decisions are not harmful for the environment. Similarly, the protection of environment must be possible for existing economic resources. The model must reflect the interlink between economy and environment.

Forestry and LUC are directly connected with the country economy. Forests are a source of wood, and wood is the raw material for production of paper, furniture, construction works etc. Land is used for cultivating different agricultural crops and feedstock, placing living houses, industrial objects and infrastructure, or other alternative uses. The growing demand for wood causes overexploitation of forests leading to forest degradation and increasing CO₂ emissions in forestry. Changing one type of land use to another, in particular forest to agricultural land or building infrastructure on forest land also causes loss of biomass and soil organic carbon, therefore increasing CO₂ emissions. There is a conflict between reducing CO₂ emissions and satisfaction of economic needs, in particular forestry commodities. Both spheres are important for the country. Avoiding overexploitation of forest resources is the necessary condition of sustainable use of forests. This can be achieved by selecting forest management to assure that harvest rate never exceeds annual increment in a particular forest. By optimizing forest management over a large territory we can maximize wood production (or fulfill wood demand) and at the same time allow the forests to build up biomass. G4M provides tools for searching such optimal forest management.

Net present value of alternative land uses may be applied as a criterion for selection of most profitable land use in a cell [16]. The Kyoto Protocol also includes different economic mechanisms that encourage developing countries to reduce CO₂ emissions [20].

The next question is the adequate projection of LUC and forestry CO_2 emissions requires without taking into account tight interlink between environment, society and economy. Therefore for modelling LUC and forestry CO_2 emissions we will use scenarios of socio-economic development.

A few sets of socio-economic scenarios are developed by the Intergovernmental Panel on Climate Change (IPCC) and the United Nation Environment Programme (UNEP). In 2000 a "Special Report on Emission Scenarios" was published by IPCC. These scenarios were used by IPCC for preparing the IPCC Third Assessment Report and the IPCC Fourth Assessment Report [5]. The Scenarios are grouped into four storylines – A1, A2, B1, B2 and each storyline has a few subsets, some of them are more environmentally friendly but no one of them is chosen the best for future emissions [18]. The storylines describe different pathways of development of economy, energy, world integrity, technologies, social and cultural interactions and population growth [18]. The scenarios do not include the effect of different climate change initiatives and future disasters [18].

The other type of scenarios was developed by UNEP and used in the Third Global Environmental Outlook and Fourth Global Environmental Outlook [14]. Four different scenarios were developed: Market First, Policy First, Security First and Sustainability First [14]. They demonstrate different types of interactions between economy, society and environment that depend on the priorities in policy of countries [14]. These scenarios were used by IMAGE model in the study "Four Scenarios for Europe" [10].

The above-mentioned scenarios are most frequently used in environmental studies. All the socio-economic scenarios have some advantages and disadvantages, use of a set of scenarios covering a vast range of possible developments gives the opportunity to choose action plan for the country in question, which allows elaboration of realistic measures for reduction of CO_2 emissions in LUC and forestry.

Demand for wood and agricultural commodities, forest growth and forest biomass are constantly changing. While the dynamics of the demand is determined by economic conditions the dynamics of forest growth and biomass depend on environmental conditions and forest management. For simulation of the future CO_2 emissions economic parameters are derived from the scenarios of socio-economic development. Because of the dynamics of the drivers of LUC and forest management, the object of modeling also changes in each grid cell, according to specified conditions. For example, there may be a change of land use from agriculture to forest, or alteration of rotation length of forest or area harvested annually. Land use change decisions depend on socio-economic development that is provided in a form of scenarios. Simulation under a wide set of socio-economic scenarios allows finding an interlink of CO_2 emissions and socio-economic conditions that helps in determining optimal policies for minimizing CO_2 emissions under the scenarios.

Making land use (change) decision in each grid cell is made after processing the input data. This decision influences the CO_2 emissions in a current year and in the future because disturbed carbon pools (litter, soil, coarse woody debris, wood products, live biomass etc.) have different time characteristics that determines transition from one state to another.

CONCLUSIONS

Information technologies, in particular modelling, are widely used for solving environmental problems. A number of global and regional models were developed for LULUCF sector. But a model for projecting CO_2 emissions from land-use change and forestry in Ukraine under different socio-economic scenarios which takes into account specialties of Ukraine has not been developed yet. Such model is necessary and important for a number of reasons.

LULUCF sector is one of the largest sources of increasing CO_2 emissions. At the same time this sector has a high potential for reducing CO_2 emissions or even sequestering carbon dioxide. Problems of accounting and monitoring CO_2 emissions in LULUCF sector are widely discussed during international meetings in the framework of the Kyoto Protocol and UNFCCC. Ukraine as a Party of the international climate agreements has a necessity to explore future level of emissions and drivers which influence LULUCF CO₂ emissions

Mathematical modelling will help to predict CO_2 emissions and find the ways of forestry development towards certain goals (e.g. carbon sequestration) under different socio-economic conditions.

Taking into account the existing experience in LU-LUCF modelling is important for development of optimal structure of the future model and choice of methods for technical realization of the model.

Use of information technologies for studying LUC and forestry CO_2 emissions in Ukraine allows processing a big amount of data that is important for adequate analysis of CO_2 emissions, understanding drivers and processes of CO_2 emissions, and interlinks of LUC, forestry and environment.

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The optimal power control method in multiuser cellular networks

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Abstract. In this paper a method of power control policies optimization in radiointerface of mobile network with code-division multiplexing is proposed. It allows reducing the interference level in downlink and uplink channels. The optimum SNR is provided in the cell based on this power control method. The SNR is enough to ensure capacity requirements and service quality parameters.

Key words: WCDMA, MIMO, power control policy, signal to noise ratio, traffic localization.

INTRODUCTION

With the advent of new communications services and increasing requirements for radio interface, the power scheduling policy plays one of most important roles in the efficiently radio resource allocation process in future wireless networks. The inner characteristics of radio interface in code division multiple access cellular systems, in terms of radio resource limitations, and non-stationary channel conditions, give rise to actual scientific problem – power control in both the uplink and downlink communication, for efficient resource allocation and interference management.

Power control problem arose due to the need to cope with interchannel interference, which users cause within the same bandwidth. Since in systems with code division, base and mobile stations powers are significantly lower in comparison with systems which use Frequency Division Multiplexing, a problem of significant difference in power levels of near mobile stations and mobile stations that are on the edge of the cell arises. In the absence of power control algorithms of base and mobile stations, users' services, which are on the edge of a cell, are impossible.

In recent years, many power control approaches in radio channels of mobile networks were proposed. All are directed to solve the problem of noise occurrence between users. In several works [1-3] effective solutions for power control optimization in uplink channel based on the game theory were proposed. A solution for power control in downlink channel was proposed [4,5] which reduces the level of interchannel interference. However, these approaches are not optimal for the integrated optimization of power control for both the channels.

POWER DISTRIBUTION OPTIMIZATION BETWEEN USERS WITHIN SINGLE CELL

Determination of optimum power for all users in wireless system is a multi-objective optimization problem, which requires cumbersome calculations. We use an iterative algorithm of power distribution in systems with multipath diagram formation in order to simplify the calculations.

Consider the sum cell capacity, which divides into three sectors:

$$C_{sum} = C_1 + C_2 + C_3, (1)$$

where: C_i - sum capacity of one sector [6]:

$$C = \Delta F \cdot \log_2(1 + \sum_k h_k), \qquad (2)$$

where: ΔF - bandwidth, h_k - SNR for user k. SNR of user is defined as follows [7]:

$$h = \frac{E_c}{N_0 + I},\tag{3}$$

where: E_c – energy of one chip of pseudorandom sequence, N_0 - spectral power density of thermal noise, I – interference, which results from the influence of other subscribers.

The formula (3) defines the ratio of erroneously transmitted bits to their total amount. We write the energy that falls on one chip through the power:

$$E_c = \frac{P_s}{R},\tag{4}$$

where: Ps - signal power, R - chip rate.

Formula (2) is the Shannon formula expressed through the SNR for separate users [8]. Sk depends on the power distribution in the sector, thermal noise level and interference from other users, which can vary according to the channel state. If the signal spectrum is uniformly distributed in the band ΔF , SNR for a particular user is written as follows [9]:

$$h_{k} = \frac{P_{s} \cdot \Delta F}{R \cdot \left(\Delta F \cdot \eta_{r} + \sum_{i=0}^{N-1} P_{i}\right)}, i \neq k,$$
(5)

where: η_r - thermal noise level of the receiver, ΣPi – interference level from other *N-1* users. Formula (5) allows expressing the power of one user through the ratio of erroneously transmitted bits to their total number. So we use BER metric in power control policy of the user [10]. The total power control policy within a single cell is the optimum allocation of radio resources among sectors proportional to the number of users. The number of sectors can be selected arbitrarily depending on the traffic density in the cell. In order to simplify the algorithm of optimal power determination of the user, we present its coordinates in the polar coordinate system [11]:

$$x = r \cdot \cos \varphi,$$

$$y = r \cdot \sin \varphi.$$
 (6)

Thus, we simplify the power calculation of the user in one sector, by limiting the area of determination its coordinate φ by one sector. User power in the polar coordinate system is defined by the radius *r* proportional to its distance from the base station, as a percent of maximum user power on the edge of a cell: Users allocation for a typical three sector-cell is shown in Figure 1.

For given random cell we calculate power level for each user, by formula (7). Results was presented in Fig.2. Proposed method allows to optimize power control in mobile network cells individual for each user.



Fig. 1. Users allocation in the polar coordinate system and determination of their optimum power

As seen in Fig.2, the average power level for given cell equal to $0.16P_{max}$. The proposed method can independently optimize power control in mobile network cells for particular users in different sectors. The optimum SNR is provided in the cell based on this power control method [12,13]. The SNR is enough to ensure capacity requirements and service quality parameters. In the following section, we analyze the space-time localization user traffic of one cell and propose optimization methods for power allocation in the cell by means of effective mechanisms of digital diagram formation.



Fig. 2. User power level for average urban cell

THE MODEL OF SPACE-TIME LOCALIZATION OF USER TRAFFIC WITHIN ONE SERVICE AREA

Any power control in mobile networks is multiobjective optimization task [14, 15]. It should be noted that it is very difficult to design the only power control algorithm for network as a whole. To effectively solve this problem, we consider not only the distance measurement to the mobile station based on the BER metric, but also such an important parameter as space-time localization of user traffic. We propose a space-time localization model of user traffic in a cell in order to provide effective performance of power control mechanism in the network (Fig. 3). This model allows depicting the spacetime localization of user traffic cell during the day and remembering statistical parameters of the traffic cell.

This aspect is important in terms of formation optimization of the antenna direction diagram [16] of the base station in order to provide greater excess power in areas with high user traffic. Thus, individual power control policy is formed for each cell in the network. It helps significantly to optimize network resource allocation.

As was noted above, it is useful to apply MIMO technology [17] with mechanisms of digital diagram formation. MIMO technology consists in the use of multiple antennas at the transmitting and receiving sides. The structure of typical MIMO antenna array presented in Fig. 5.



Fig. 3. Space-time localization of user traffic of service area during one day



Fig. 4. General case of 3-sector cell model without beamforming



Fig. 5. Structure of 12 element transmission/receiving antenna array

Process of beam forming comes to FFT computation of received complex voltage counting, obtained at same time interval. Thus the set of antenna diagram space characteristics $F_r(\theta)$ is forming. For linear equidistant antenna array $F_r(\theta)$ defined as follows [18]:

$$F_r(\theta) = \tan\left(\frac{dR}{\lambda}\sin\theta\right) \cdot \tan r \cdot \left[\frac{\cot r - \cot\left(\frac{dR}{\lambda}\sin\theta\right)}{\tan\left(\frac{dR}{\lambda}\sin\theta\right) - \tan r}\right], \quad (8)$$

where: r – number of linear equidistant antenna array space channel (r=0,R), θ - angular coordinate. The result of proposed method implementation presented in Fig. 6.



Fig. 6. Power optimization in cell by using method of digital beam forming based on space traffic localization

Local maximums of objective function $H(\theta)$ finding by Keypons' algorithm [19]:

$$H(\theta) = \left(F^{T}(\theta) \cdot K^{-1} \cdot F(\theta)\right)^{-1}, \qquad (9)$$

where: $F(\theta)$ - vector of spatial diagram values of digital antenna array with elements $Fr(\theta)$. K – correlation matrix defined as [20]:

$$K = \frac{1}{N} \sum_{n=1}^{N} U_n \cdot U_n^{*},$$
(10)

where: N - number of time intervals; U – vector of signal voltages obtained as result of FFT computation of voltages on initial output receiving channels of digital antenna array; * - complex conjugation operation.

CONCLUSIONS

In this paper we propose a method of power control policy optimization in the radio interface of a mobile network with code-division multiplexing. It allows for the reduction of interference level in a cell and increase of the efficiency of radio resource management of mobile network. We consider the users activity during the day, including the distance to the base station. For simplicity, we have designed the model of space-time localization of user traffic intensity. Based on this model we propose the method of antenna diagram beam forming, which allows to cover only the users traffic, and ignore zones without activity. The proposed method can independently optimize power control in mobile network cells for particular users for different sectors and increase the power level for 1 Erl of user traffic intensity.

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Peculiarities of development and reforming markets of electric energy as one of the key energy products in the European Union

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A b s t r a c t. The article discusses the historical background and problems of reforming electricity markets in the European Union. It elaborates on the dynamics of the main indicators and analyses the main trends in the EU electricity sector. The article presents statistics on the energy production and consumption in the EU and examines the legal framework of the electricity industry reform.

Key words: electric energy markets, reforming energy markets in the EU, liberalization of electric markets.

INTRODUCTION

Electric power industry is the infrastructure component of the economic system in any country. Effective operation of this industry has direct influence on country's economic performance, well-being of people and societies [1]. Therefore, the development of the robust and efficient electricity market is commonly treated as an important task for every economy worldwide. The relevance of energy issues to the global development agenda can be proved by many international policy papers, like the United Nations General Assembly resolution 65/151 [2]. This document declared 2012 the year of sustainable energy in response to the growing importance of energy issues nowadays. The following industry objectives are set be met by 2030 [2]:

- Provide access to modern energy services,
- Double the level of energy efficiency,
- Double the share of renewables in the global energy balance.

The world and European Union energy balances in 2010 are shown below (Fig. 1 and Fig. 2) [3]. The EU uses nearly five times more nuclear power and almost three times less crude oil.

The need for radical changes is caused by the fact that in 2010 the share of renewable energy sources is less than 15% worldwide and less than 20% in the EU. However, problems arise not only from the energy balances of countries. The competition levels in some energy markets are sources of concern as well. For example, natural gas markets still remain heavily monopolized. As far as the secondary energy products (produced from primary sources) are concerned, electricity generating companies are very prominent natural monopolies.



Fig. 1. World energy balance structure [3]



Fig. 2. EU energy balance structure – 27 [3]

ANALYSIS OF THE LATEST RESEARCH

Such economists as V. Verbynsky, G. Gasanov, G. Geletuha, D. Dolisznij, S. Jermilov, G. Zemlyany, S. Kazansky, O. Kendiuhov, E. Krykavsky, O. Kuzmin, O. Lapko, S. Melnikova, I. Nedin, A. Rabia, A. Ryzova, O. Solovej, P. Serra, P. Starovojtov, V. Toczylin, V. Petrenko, R. Fisher, E. Chlobystov, V. Caplin, A. Czuchno, N. Czuhraj, A. Szevcov, A. Szydlovsky, A. Szot, N. Shpak have paid much attention to the problem of raising competitiveness among producers of electric energy over the last few years.

Despite the significant amount of studies about the international experience, there's a lack of research papers providing complex analysis and scrutiny of the electricity markets in the European Union.

THE PURPOSE OF THE STUDY

The main purpose of this paper is to analyze and to generalize international (especially European) experience in establishing market relations in the electric energy sector.

THE RESULTS AND DISCUSSION

Energy plays a vital role in the economic life of every country, influences the daily life of people and impacts the environment. Energy interacts with all three major components of sustainable development (economic, social and environmental) [2]. Therefore, it is important to the development of any country. Electricity is one of the most versatile forms of energy [4, 5, 6].

Research about the development of electricity markets in EU countries showed that up until the end of 80-ies the industry was influenced by the centralization trends in almost all countries. This was caused largely by the concerns about the energy independence and, therefore, the national security of countries after the Second World War. Centralization allowed to achieve higher efficiency by introducing economies of scale in the production of electricity. Reliability of electricity supply at fixed prices was yet another advantage of centralization. However, the innovation in the electricity sector made it possible for the medium-size power plants to compete with the larger plants. Still the centralization trends in the development of the electricity sector posed significant problems. This mainly applies to prices (which were controlled by the governments) and quality of supply and services. Consumers were passive objects in the market, which was manipulated by governments and energy companies. That monopoly in the electric power industry led to higher prices coupled with low quality power supply. Realizing the shortcomings for the centralization, governments began a gradual withdrawal of the electricity industry from natural monopolies in the early 90-ies [1]. Power generating and sales to large consumers were in

the vanguard of the electricity market reforms in most EU countries.

Governments of different countries reconsidered the natural monopoly character of power generating and started to introduce the elements of competition to the industry in the early 90-ies. The pioneers in decentralization of the industry were England and Wales (1990). In 1991 they were joined by Norway, followed by Finland (1995), Sweden (1996), Germany, Spain (1998), Denmark, Austria, Luxembourg, Netherlands, Italy, Portugal (1999), Belgium and Ireland (2000) Greece (2001) [7]. The liberalization of electricity markets in Europe allowed to achieve the following objectives:

- Reducing the cost of electricity,
- Increasing the efficiency of power supply and transporting,
- Attracting foreign investment in this sector,
- Giving consumers the right to choose suppliers,
- Improving the quality of service,
- Increasing the competitiveness of domestic producers of electricity.

The changes in the energy sector in different EU countries were caused by a significant number of factors. The most important were the following:

- technological changes in the electricity generating process,
- organizational changes in the production and transmission of electricity,
- utilization of new sources of energy (natural gas, solar and wind energy, etc),
- introduction of the international electricity trading,
- development of the new infrastructure (primarily, for trading and information exchange).

The above mentioned factors in the electricity markets accelerated the adoption of the competition mechanisms in the EU.

Reforms in the electricity sector of the European Union supported by the respective legislation. Specifically, European Parliament adopted a directive 96/92/EC in 1996. (Directive 96/92/EC of the European Parliament of the Council of December 1996) [8]. It defined the ways of markets restructuring. The basic idea of the directive was to give customers a free choice of electricity suppliers. According to the Directive, the free choice availability was to reach a level of 30% of the electricity market in 2000 as a result of market liberalization. However, the reform process was much faster and the share hit 80% in 2000.

This reform also led to an increase in production and consumption (Fig. 3, Fig. 4) and free flow of electric energy between the EU countries. This in turn facilitated efficient use of power capacity of each of the participating countries.

Directive 2003/54/EC of the European Parliament from 26 June 2003 concerning common rules for the internal market in electricity and repealing Directive 96/92/EC is another legal act that governs the electric energy industry of the European Union [9]. This Directive establishes the requirement of electricity market liberalization in the EU with further integration of local



Fig. 3. Dynamics of the electric power production volumes in the EU in 1999-2010 years



Fig. 4. Dynamics of the electric power consumption volumes in the EU in 1999-2010 years

markets. Measures spelled out in the Directive aimed to achieve the following:

- increase of efficiency of electric energy production,
- price abatement on electric power,
- improvement of service quality,
- increase the competition on the electric power markets. The main directions of the reform were the following:

the liberalization of national electricity markets of the EU, the development of regional markets, coordination between markets and integration on the European level [10]. The vertically integrated companies were primarily differentiated by type of activity. Reforms required the level of competition in the market, the economic justification for the cost of electricity and the possibility of free choice of provider, reducing CO2 emissions and so on. Some countries struggled with the implementation of these objectives. First of all it concerned the national character of generating electricity (network, infrastructure). Another problem was the lack of transparency in the electricity sales. To solve these issues, the European Commission adopted the Directive 2009/72/EC on 13 July 2009 [11]. However, unlike the execution of Directive 96/92/EC, the proposed guidelines unfortunately are not followed by many EU countries [11, 12]. All obligations are fulfilled by only eight out of twenty seven member states. These countries are Czech Republic, Denmark, Germany, Greece, Hungary, Italy, Malta and Portugal. The worst implementation record is in Bulgaria, Cyprus, Luxembourg, Netherlands, Romania, Spain and Slovakia.



Fig. 5. Renewables and Waste in the European Union - 27 in 2010 year

Requirements of the Directive 96/92/EC apply to different energy markets. However, the positive changes occur primarily in the electric power sector due to the maturity of the respective market and relatively smaller conflict of interest between the market players.

The integration processes are becoming more prominent in the energy sector as well. This can be illustrated by the single price association in the North-West Europe. According to forecasts, the final reform and the creation of a single price zone will happen by the end of 2014.

The EU member states require larger amounts of energy from year to year. Given the shortage of the traditional energy supply, the need for renewable energy is



Fig. 6. Electricity generated from renewable sources (1990-2010), % of gross electricity consumption.



Fig. 7. Share of renewable energy in gross final energy consumption in the EU (2004-2010), %

becoming more prominent [24]. For example, in the recent years a share of wind energy has increased to 1/5 (Fig. 5).

The volumes renewal energy sources grow from year to year (Fig. 6) [14]. Moreover, the consumption of renewable energy also increases (Fig. 7) [15]. The leaders in renewable energy consumption are Norway (61,1%), Sweden (47,9%), Latvia (32,6%), Finland (32,2%) Austria (30,1%), Portugal (24,6%), Estonia (24,3%), Romania (23,4%) and Denmark (22,2%)

As previously noted, nuclear energy has a large share in the energy balance of the EU countries. The largest nuclear power generating capacity is concentrated in the countries like Switzerland (20%), Sweden (over 30%), France and Finland (16%), Belgium (36%), Germany (22%) [1]. At the same time, the governments of some countries like Germany and Switzerland have decided to withdraw nuclear energy from their own energy balances in the future. However, due to the different approaches to nuclear power and limited opportunities to influence the nuclear market, the EU is not yet expected to have a common nuclear energy policy for all 27 member states [16]. The same applies to the development of markets of other energy products.

CONCLUSIONS

Research showed that the electric power markets are most liberalized in such countries as Germany, Great Britain, Norway, Sweden, Finland, Spain. Markets of France, Italy, Portugal, and Greece remain less open. However, unlike the execution of Directive 96/92/EC many requirements of the Directive 2009/72/EC not met by many EU countries. All obligations are fulfilled by only eight out of twenty seven member states. These countries are Czech Republic, Denmark, Germany, Greece, Hungary, Italy, Malta and Portugal. The worst implementation record is in Bulgaria, Cyprus, Luxembourg, Netherlands, Romania, Spain and Slovakia.

Despite all the differences in the electricity markets reforms in the EU, there is one thing in common. This is the separation of natural monopoly (electricity transmission and distribution management) and potentially competitive activities (power generating, sales and repair services), as well as the liberalization of the electricity markets. The success of the EU reforms is proved by a steady increase in production and consumption.

Another trend in the development of energy markets in the EU is the formation of the electricity exchange. Bilateral contracts are signed during the direct negotiations between parties. Electricity exchange is a tool which
helps to sell standardized contracts for generation and supply easily and quickly.

Potential areas for further research are the possibilities to apply the EU experience in reforming the electricity market of Ukraine. This will facilitate the development of the electricity market of Ukraine and its further integration into the EU.

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Editors of the "Econtechmod" magazine of the Commission of Motorization and Energetics in Agriculture would like to inform both the authors and readers that an agreement was signed with the Interdisciplinary Centre for Mathematical and Computational Modelling at the Warsaw University referred to as "ICM". Therefore, ICM is the owner and operator of the IT system needed to conduct and support a digital scientific library accessible to users via the Internet called the "ICM Internet Platform", which ensures the safety of development, storage and retrieval of published materials provided to users. ICM is obliged to put all the articles printed in the "Econtechmod" on the ICM Internet Platform. ICM develops metadata, which are then indexed in the "BazTech" database.

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ANTITERRORISTIC PASSENGERS' SAFETY OF THE RAILROAD TRANSPORT

Railroad train operation is a huge problem in the terms of emergent situations, effective solving of which is fully dependent upon driver's qualification, experience and his being informed about the event happened at present. But not in all cases driver's qualification and experience are the guarantee of logically correct train operation in case of performing terrorist act.

The suggested invention allows to solve this problem



Unit-scheme of the apparatus

1 - the source of explosion; 2 – sensor for explosion registration in carriage saloon; 3 – sensors for the control of the position of wheels in rail track and registing derailment; 4 – operation unit; 5 – train control desk.

How apparatus works within performing terrorist act

Within putting explosive apparatus into action the working out of sensors 2 take place in carriage saloon. Signal from sensors 2 and sensors 3 is transmitted on operation unit 4. In case if sensors 3 registered derailment train braking is done immediately.

If after putting explosive apparatus into action sensors 3 inform about the fact that there has been no any derailment, train braking is done with the account of country relief. It is connected with the fact that the place of train stop is of great importance for conducting further evacuative undertakings and saving works. For instance, train stop in the tunnel or at track plot, having high slopes, can only make evacuative works and saving undertakings more difficult and moreover it can worsen the consequences.

In connection with this fact the information about unfavorable places of emergent stop is written in central train computer in ahead. Further, this information is used in automatic regime of search of train damage stop.

Simultaneously with the fulfilling actions in train operation, radio information about the event happened is sent to the nearest dispatching center automatically with the purpose of taking measures in giving help.



Recycling of copper conductors' scrap to powder without melting and refining



The waste-less technology including the operations of annealing, purification and grinding.

The powders and fibers were used for production of



nanostructural copper, materials with nanostructure elements of elevated wear resistance, rods.

Recycling of grinding swarfs into powder steel that contains chrome, molybdenum



waste-less technology The including the operations of grinding with washing, separation, disoxidation. The have powder used for production details of of transport machine-building.



Processing the swarf of aluminium alloys into the powder



The waste-less technology including grinding, annealing, classification by fractions.

The finished item - rod

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ONE-STAGE PRODUCTION OF HYDROGEN WITHIN LIQUID AND HIGH TEMPERATURE HEAT-TRANSFER MEDIUM

Background of new technology decision search of hydrogen production in chemical industry

- raising prices of crude oil, natural gas and energy carriers
- the necessity to increase the completeness of raw material processing
- multistage way and difficulties of modern processes of natural gas conversion
- decreasing energy expenses
- high expenses for new heterogeneous catalysts production and equipment for high temperature gas-phases processes
- costs dealt with buying licenses of foreign technologies process.

Study of hydrocarbons processing within liquid and high temperature heat-transfer medium

The best results achieved:

- One-stage production of hydrogen and decrease of costs for construction and exploitation
- Degree of natural gas conversion into hydrogen and carbon within sodium chloride melt is 100%
- 10-100 times reactor volume reducing
- The possibility and advisability of producing hydrogen from fuel gases of oil refining
- Maintaining constant high heat and energy stressed surface of phase contact

Technology and fuel (raw materials)	Power 1000 Kg/day	capital costs		Factor	Hydrogen production costs (\$ for 1 Kg of H ₂)			
		MLN \$	\$ for 1000 Kg/day	of power (%)	Capital	Of raw materials	Operational	Total
Pyrolysis of NG	379,387	\$200	\$530	90	\$0,20	\$1,80	\$0,25	\$2,25
Conversion of NG	379,387	\$288,3	\$760	90	\$0,40	\$1,72	\$0,51	\$2,63
Gasification of Coal	283,830	\$436	\$1,536	90	\$0,57	\$0,56	\$0,09	\$1,21
Gasification of biomass	155,236	\$155	\$998	90	\$0,37	\$0,52	\$0,55	\$1,44
Electrolysis	1,500	\$2,74	\$1,827	70	\$0,96	\$5,06	\$0,73	\$6,75
Nuclear thermochemistry	1200,000	\$2,468	\$2,057	90	\$0,76	\$0,20	\$0,43	\$1,39



The radical improvement of the efficient use of hard fuel can be attained only by the using principally new technologies. Plasma technology is the most perspective among the alternative ones. It provides a substantial economy due to the reduce of fuel part in the energy cost and the improvement of HEC ecological indexes working on hard fuel.

Plasmotron and enstallment on a direct coal gas-ring



Reduce of the formation of NO $_{\rm x}$ and mekhnedoghega



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Offers services in the scope of:

choice and optimising of chemical composition of non-ferrous metals and development of new cast non-ferrous metal alloys (Al, Mg, Zn, Cu), also melting techniques, melt treatment (refining and modification), casting and heat treatment, analysis of offered solutions in terms of technology and economy;

▶ technologies for fabrication and processing of cast metal matrix composites;

- development of technical and technological guidelines and start up of work posts for casting non-ferrous metal alloys and respective composites, including:
 - gravity casting into sand moulds, permanent moulds (dies), and ceramic investment moulds;
 - high-pressure diecasting, including special variations, like:
 - casting in the atmosphere of active gas (Vacox process),
 - low-energy processes (intermediate between high-pressure diecasting and squeeze casting);
 - thixocasting;
 - low-pressure diecasting;
 - squeeze casting;
 - centrifugal casting;





Department of Non-Ferrous Metal Alloys

- fabrication and homogenising treatment of metal-ceramic compositions, including nanomaterials;
- recycling process scrap of non-ferrous metal alloys;
- testing thermal shock resistance of alloys;
- traditional and special methods of the heat treatment of cast non-ferrous metal alloys and optimising their technological parameters to best satisfy the performance requirements of the ready castings;
- small lot production of castings from monolithic alloys (Al, Mg, Zn and Cu) and composite materials;
- measurement of hydrogen and non-metallic inclusions content in aluminium alloys, and of the density index of these alloys;
- the derivative thermal analysis (DTA) of non-ferrous metal alloys.

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Department of Technology

Conducts research, development and application works in:

- modern technologies of mould- and core-making (cold-box, warm-box, shell moulding, self- and chemo-setting sands);
- conventional mould-making technologies;
- sand reclamation from waste moulding and core mixtures, starting with feasibility study and determination of reclamation methods adopted to the production profile of a specific foundry, through conceptual design project, supervising the construction of reclamation line, and in the use of reclaim under the specific conditions of foundry production ending;
- processing of waste sand for use in other sectors of industry;
- management of industrial waste in foundry sector;
- modern machines, equipment and control-measuring apparatus for foundry industry;
- technology of making castings from alloys of ferrous and non-ferrous metals in sand and permanent moulds;
- modern methods to examine physical, chemical and technological properties of moulding materials and sand compositions;





Department of Technology

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- organic and inorganic binders, and auxiliary materials;
- mechanisation of moulding technologies;
- development of modern raw materials for moulding sands and of technologies for their manufacture;
- development of technologies, making new casting assortments and improvements introduced to processes already in use to improve quality, raise the cast metal yield, reduce the emission level of toxic compounds and the level of rejects;
- manufacture of test and pilot lots of aluminium castings in dies and sand moulds.

The Department is equipped with modern control and measuring instruments for simulation of true foundry processes as regards mould and core technology and foundry sand reclamation.

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